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BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

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Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., SEPTEMBER, 1918 NO. 1

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A UNIQUE OPPORTUNITY.

TO ALL INTENTS AND PURPOSES THE WAR DEPARTMENT THROUGH ITS COMMITTEE ON EDUCATION AND SPECIAL TRAINING TAKES CHARGE OF COLLEGES ON OCTOBER 1, WHEN ALL PHYSICALLY FIT MALE STUDENTS EIGHTEEN YEARS OR OVER WILL BE MEMBERS OF THE STUDENT ARMY TRAINING CORPS.

THIS MEANS THAT THE OLD COURSES OF STUDY ARE PRACTICALLY ABOLISHED AND THERE ARE SUBSTITUTED SHORT INTENSIVE COURSES WHICH WILL FIT MEN FOR SPECIFIC DUTIES WITH THE ARMY.

THE CHANGE WHICH THIS INVOLVES PROVIDES THE ENGINEERING TEACHER WITH THE GREATEST OPPORTUNITY EVER PRESENTED TO TEACHERS. MODIFICATIONS IN THE CURRICULUM, CHANGES IN METHODS OF TEACHING, INTRODUCTION OF NEW MATERIAL CAN NOW BE MADE AT ONCE WHILE IN TIMES OF PEACE IT WOULD REQUIRE YEARS OF AGITATION TO ACCOMPLISH EVEN A SMALL FRACTION OF THESE CHANGES.

THE OPPORTUNITY OPEN TO TEACHERS OF ENGINEERING IS EQUALLY OPEN TO THIS SOCIETY AS AN ORGANIZATION OF SUCH TEACHERS.

IT IS INDEED MOST FORTUNATE THAT THE JOINT COMMITTEE OF THIS AND OTHER ENGINEERING SOCIETIES SHOULD HAVE MADE ITS FINAL REPORT AT THIS TIME. THIS REPORT PRESENTS IN A COMPREHENSIVE WAY WHAT HAS BEEN ACCOMPLISHED BY ENGINEERING TEACHERS UP TO THE PRESENT TIME AND SUGGESTS THOSE MODIFICATIONS AND CHANGES WHICH APPEAR TO BE MOST NECESSARY

TO MEET THE NEEDS OF INDUSTRY FOR THOROUGHLY TRAINED MEN IN NORMAL TIMES.

THE TEACHERS OF ENGINEERING WHO HAVE BEEN IN CONTACT WITH THE TECHNICAL TRAINING CORPS ESTABLISHED LAST APRIL IN DIFFERENT SCHOOLS HAVE LEARNED MANY THINGS OF VALUE IN TRAINING MEN FOR SPECIFIC INDUSTRIES. THE NEW COURSE NOW BEING ESTABLISHED BY THE WAR DEPARTMENT SHOULD BE USED BY THE TEACHER OF ENGINEERING AS A LABORATORY IN WHICH IDEAS CAN BE WORKED OUT TO A SUCCESSFUL FORM OF INSTRUCTION.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION IS AN ORGANIZATION WITH A UNIQUE OPPORTUNITY TO COÖRDINATE THE BEST WHICH CAN BE DEVELOPED AND PREPARE THE WAY FOR THE ADOPTION OF THESE IN THE GREAT RECONSTRUCTION PERIOD WHICH IS TO FOLLOW THE WAR.

AS A MEMBER OF THIS SOCIETY IT IS YOUR DUTY TO DEVELOP AND PUBLISH FOR THE BENEFIT OF OTHERS, THOSE IDEAS WHICH MAY IN ANY WAY BE HELPFUL IN THIS CRISIS.

SUGGESTIONS FOR CONSIDERATION.

F. H. NEWELL,

Professor of Civil Engineering, University of Illinois.

The following suggestions are offered in the hopes of arousing discussion, either here or later, of some of the fundamentals of our vocation. Viewing it in a large way, the first impression of the business of engineering education had by an engineer coming from so-called ''practical life'' is the absence of definite plan and of what are usually termed ''efficiency'' methods. There seems to be little attempt at economy of effort or of time either for the students or for the instructors. This condition arises presumably from lack of general agreement as to what we are really doing or from a failure to obtain clear conceptions as to the objects we are trying to attain. There seems to be little or no coöperation effort in a large way among instructors of engineering nor coördination among the various divisions of instruction; little or none of the well-organized team play so essential to success in our highly developed business or industrial life in which our students are soon to engage.

In the present crisis there is special need of clarifying and re-stating our ideals. To stimulate such action this condensed abstract is offered.

1. We are in a war in which the whole world is concerned.
2. This war in magnitude, intensity and destructiveness exceeds every other calamity.
3. It is likely to continue indefinitely with increasing destructiveness.
4. It is not a war of brute strength, but of engineering devices.
5. The side more likely to win is that which most quickly

invents and successfully utilizes various engineering devices. Time is an essential element.

6. To invent and to successfully utilize these devices more and more engineers are needed.

7. Whenever the war terminates there will be additional needs for engineering skill to repair the destruction wrought.

8. The rapid changes which are taking place in all affairs are being accompanied by equally far reaching changes in engineering methods.

9. These changes are of supreme concern in engineering education.

10. Educational methods should be quickly and effectively modified to anticipate or meet the demands of this new world of experience and ideals.

11. The government of the United States and many of the larger industries, connected directly or indirectly with the war, are calling for young engineers qualified to meet modern needs.

12. It is the business of the members of the Society for the Promotion of Engineering Education to manufacture young engineers from the raw materials.

13. It is important to do this as rapidly and effectively as possible, to begin now to increase the speed.

14. If the above statements are correct, it is our duty to lose no time in this important matter; but first we may ask

15. What is the Society for the Promotion of Engineering Education and what are its objects?

16. The constitution does not state any object; this must be inferred from the name and character of membership.

17. The membership comprises those persons who occupy or have occupied responsible positions in the work of engineering instruction, together with engineering practitioners and others interested in engineering education.

18. These members are brought together to promote engineering education. Are we doing it? To answer this we must agree as to what is included in "promotion."

19. Promotion, according to the dictionary, is to contribute to the growth, enlargement or prosperity, to encourage, to advance, as "to promote learning."

20. There is also a somewhat peculiar secondary meaning in American usage in that to *promote* any enterprise implies doing it with vigor and with the full use of all resources available regardless of consequences.

21. In the full sense are we really *promoting* engineering education? Are we contributing to its growth, to its enlargement, are we advancing it or is the rapid evolution of engineering methods dragging us with lagging feet in its train?

22. To promote any enterpise of the kind we must have

(*a*) materials,

(*b*) methods and

(*c*) men.

Are we advancing in each of these?

23. In (*a*) materials we are falling behind in the sense that the materials we work upon are young men. We have a fewer number each month. Are we using our resources ef-effectively to get young men?

24. As a rule engineering colleges have pursued a dignified course and have not gone in an active, businesslike way into the high schools, or into "the high-ways and by-ways" to get needed material.

25. Are we doing our full duty if we do not exhaust every reasonable, and some unreasonable, means to let the grown boys know of the opportunities offered in engineering education and the needs of the nation? Are we truly promoting our work unless we do this?

26. After getting the students, are we using our full efforts to keep the best of these in college by urging the adoption or improvement of a system of detailing the enlisted men to intensive college training until they graduate?

27. In (*b*) methods we are less derelict; we have devoted most of our energies to discussion of these—but have we really

kept up with the new generation and are we actually putting into practice the theories which we are discussing?

28. In our present methods—a relic of the scholastic past,—are we not wasting time of the students and instructors in lost motion—in non-essentials, in vacations, etc.? By speeding up can we not accomplish in three years all we are now trying to do in four years?

29. In (*c*) *men* are we keeping up? To get and keep good instructors we must see that they have more than a bare living wage. Are we doing this? Are we not keeping as instructors the rejects from better paid engineering work?

30. The depreciation in purchasing power of gold is such that salaries of say $1,600 today are equivalent to not much more than $1,000 in a former decade. Our instructors with increased experience are getting less than in former years. What are we doing to promote engineering education in keeping those necessary men?

31. In this day and crisis in human affairs we are expected to try to be 100 per cent. efficient; are we doing it, or are we presenting an attitude of apology for occupying the time and space which might be better used?

32. In conclusion to ''promote'' engineering education we should concentrate on effective schemes for

(*a*) More materials—more students to be attracted and held.

(*b*) Better methods—less wasted time.

(*c*) Better men—more pay for instructors to keep up with past salaries and to prevent the better men from going out of educational work.

In the consideration of some of the items just given—comments have been made in conservation. Notably President Charles S. Howe of Case School of Applied Science, referring to the need of getting more materials to work upon (paragraph 23) has told how he has already initiated a thorough canvass of high-school students. The success of this can be ascertained only after the beginning of next winter's work.

On the whole the persons who have discussed such efforts have seemed to think that they are well worth attempting. Moreover under the conditions of modern life, it has been found that every similar enterprise must conduct well-planned publicity of advertising campaigns to secure an adequate supply of the material upon which to work.

In November, 1917, Prof. H. H. Jordan, assistant dean of the College of Engineering, University of Illinois, secured from 297 students in the freshman engineering class replies to questions intended to bring out the reasons why they came to the university and also as to why they chose engineering instead of some other college.

The answers indicate clearly that the students, in their own minds at least, were convinced that they had made the decision to enter the college without much help from parents or teachers. The controlling factor seems to be the advice or suggestions from people who have never attended college and particularly from persons connected with contracting or engineering firms. It appears that about half the high schools have tried to bring to the attention of students the advantage of a college education and that a few instructors in these high schools have attempted to analyze the native ability of the boys and to advise accordingly.

The reason as to why the engineering college has been chosen is largely because the young men, through work with engineers or contractors, have become interested in this occupation. Nearly two thirds of the engineering students have one or more relatives engaged in engineering. Only 12 per cent. indicated that the occupation of their father was engineering, while 95 per cent. of the freshman class had parents neither of whom had been to college. A large majority, or about 80 per cent., of the students assert that they have definite knowledge of the fact that the financial returns in the engineering profession are less than those in other professions.

If the above noted conditions are typical, it appears that in order to attract more young men and to arouse in the high-school students an interest and appreciation of the value of engineering education, certain systematic work should be pursued more largely through engineers and contractors, calling to the attention of each of them his particular duty as a citizen to make known to the bright boys in his neighborhood the opportunities offered by the engineering colleges, also the advantages possessed by a young man who has made use of these opportunities. It appears that the American boy is guided more by examples and by advice of this kind than by anything his parents or teachers can or do say to him. It is the environment outside of school and home which appears to influence his choice of future occupation.

With reference to economy of time (paragraph 28) several educational institutions have already begun to seriously consider this. The most interesting case perhaps is that of the University of Missouri which in its new three-term calendar states:

''The war has made it necessary to increase efficiency in educational enterprises as well as in enterprises of other kinds. The necessity of conserving time and eliminating the waste of holiday and closed seasons has led the University of Missouri to adopt an all-year calendar, which, it is believed, will prove equally desirable as a peace-time program.

''Beginning with the next regular session, which will open for registration August 30, 1918, the school year of the university will be divided into three terms of sixteen weeks each, instead of two semesters, of approximately the same actual length, as heretofore. Under this plan the university's educational machinery will be in operation during the entire year, with the exception of two weeks in the latter part of August and a week at Christmas.

''These terms will be known as the fall, winter, spring and summer terms. Students may take only one term a year or all three, though it is believed that in most cases best results will be obtained by studying not more than two and one half terms consecutively.''

An equally important but perhaps more difficult question is that brought up in paragraph 29 with reference to getting and keeping good instructors. The time has arrived when the full sunlight of publicity should be turned upon the profession of engineering education. A careful examination should be made not only into the present conditions, qualifications, activities, and pay of the instructors, but also into that of men who may be utilized as instructors, together with a comparison with similar conditions in private and public service. In this age of organization when in almost every line of human activity united efforts are essential to human progress, the engineering profession stands out prominently through its disorganized condition or rather multitude of unrelated societies and lack of unity on all important questions.

Individualism in ideals and methods has been carried to an extreme with the result that while engineers as such are performing great work for the country, yet as a body they are practically unknown and unrecognized in larger public affairs. In fact it may be said that taking the man on the street while he knows what is a doctor, a lawyer, or an architect and recognizes the authority with which their organizations speak, yet his definition of an "engineer" rarely gets beyond that of "a man who runs an engine," and his conception of an engineering organization is typified by that of the Brotherhood of Locomotive Engineers. He and his representative in the legislature or in Congress possibly never hear of an engineering society in the sense in which we here use the term.

Widely prevailing ignorance regarding engineering as a profession is due to the fact that we as engineers have made little effort to educate the public along these lines with the result that the public little knows and appreciates less what it owes to engineering, nor does it realize the vital importance to the community of getting and keeping effective engineering instructors. Failure in this respect is due to our own neglect.

We have a present duty to awaken or educate public opinion to a degree such that it will support the efforts to get and keep good instructors, securing for them a fair compensation. As long as the condition exists, as it does today, that many of our instructors can go out and obtain larger wages at skilled trades or even in simple mechanical labor, it is of course almost impossible to pick and choose our men. The fact that they can do this is in part due to the indifference of engineering organizations. This has been fostered in part by a high sense of the ethics of the profession, looking down upon everything which savors of commercialism.

There are unfortunately no standards of salaries nor data by which these vital matters may be discussed. The American Society of Civil Engineers has made some investigations into the earnings of its members, but as yet there has not been a thorough, business-like or scientific analysis of what may be termed a fair wage or the relation of responsibilities or performance in engineering education to the compensation paid. The result is,—as in all cases of this kind where there is lack of information and of organization,—that the minimum wage is paid and there is strong temptation constantly offered for the more energetic men to accept tempting offers from outside.

On the other hand our instructors are required by custom to maintain a certain appearance of respectability. They share in the condition described by Gen. W. M. Black at last year's meeting as ''nothing but genteel poverty from beginning to end.'' (Proc. S. P. E. E., Vol. XXV, p. 39.)

Again the question may be asked, ''In view of these conditions are we as a society for promoting engineering education keeping up to the full degree of efficiency, one which we are supposed to demand from our students?'' Are we not giving most of our time and thought to the minor, but more interesting details of our work, and putting to one side the vital problems of getting the necessary raw material, of finishing it off rapidly and effectively, and of getting and keeping the highest obtainable grade of instructors, ''the men behind the gun'' in our institutions?

A TECHNICALLY PREPARED RESERVE TEACHING CORPS.

BY W. J. RISLEY,

Professor of Mathematics, James Millikin University.

I know how to quit in four minutes in a theater, but whether I can do the same here I don't know.

We have talked about efficiency in engineering instruction and the instructor being prepared technically to do his business and that is my aim.

I have among my past students three or four who are holding army instructional positions, two of whom are teaching gunnery, about which I know nothing. I know which end of the gun is supposed to have the shell in it and I know out of which end the shell is supposed to go toward Berlin, and I imagine that is about the sum total of gunnery knowledge in this room.

I think if my students can go to Norfolk and take coast artillery and become sufficiently expert to teach it when they have no more mathematical and physical equipment than we give them, that perhaps I might and you might in two months learn enough without technical foundation, so that when the time comes and these boys of Pershing's age are needed in that drive which must come before we complete our business in this war, the three- or four- or five-million army which must go may be sent to Millikin and Illinois and other places, or that we may be drafted into service, taking the place of these boys who may be useful in the active military service. Hence, I believe three or five hundred, a thousand, or fewer or more of us, who may be disqualified for military service abroad, might well be placed in these various schools where we might be able to absorb enough of this information that when the time comes, we as technically educated and trained reserves, might be called upon whenever, in the judgment of the department, we should be conscripted to take the places of these men who are called into active duty.

Some one says, "Suppose the war is over before you get it done." Then I will have accumulated something which I will be pleased to hand back to Uncle Sam with good compound interest. I will have gained something that will make me a better instructor in the time to come. It is not lost.

One of my former students is an instructor in machine gun work at the University of Illinois. My oldest boy is a student in the ground school there. I know that student was sent from Columbus, Ohio, barracks to Champaign for further orders. As soon as he arrived he was informed that he would be a machine gun instructor beginning three days later. He got his first book then on machine gun instruction. That is how much he knew about it. He had from Saturday to Monday morning to keep ahead of the youngsters.

I presented this matter of military instruction to Professor Mann and it has his hearty endorsement. I also have his instructions as to how to get it through when I want to write down to Washington. I present it to you for discussion and for such action as you may care to take.

Chas. S. Howe: Mr. President, I take it that the War Department is already considering matters of this kind. Eleven engineering institutions have been asked to nominate one professor each to go to Fort Monroe this summer to take a two months' course in gunnery. The greater part of the work is to be theoretical and the men are not to be in uniform. Some of the work will be practical work with the guns. We have just nominated our man to go there. I take it this is an opening step.

They say in their circular that it is important that gunnery be taught in the engineering institutions and that they are trying to see whether they cannot find members of the faculties to be taught enough gunnery to give courses to the students and interest them in the coast artillery, which department of the Army has been making a very great effort to get our engineering graduates. I believe that before very long the War Department will extend this matter and will invite all of the engineering colleges to send members of their faculties to such schools.

C. Russ Richards: Apparently this Committee on Education is endeavoring to stop the competition of the different branches of the Army for technical men. Such action is a step towards the coördination of the needs of the Army and the apportionment of technical men to cover as nearly as possible such needs.

Of course, this is propaganda on the part of the coast artillery. They want instruction given to interest the best of the men in its branch of service.

President Howe: I take it that the institutions are going to send men down to Fort Monroe.

Dean Richards: We are going to.

T. U. Taylor: Mr. Chairman, we have had some experience with this method of recruiting raw instructors.

About seventy-five of my own ex-students are instructing in these ground schools or in similar schools, but the method does not consist of such procedure as the gentleman described who would lead us to believe that a student got there one morning and was going to instruct the next morning. These men are carefully selected after considerable investigation. They are brought there as instructors, but they do not go into the actual work for some weeks. They are put in classes first, and the government has been very careful in selecting them; they are not the raw products, but they have the foundation. They are already at least junior engineers and most of them are graduates. It is their technical training which is the foundation.

I was filled with fervor to get into one of these schools, but I was told they didn't want any men over thirty-five, so my patriotism had to have an outlet in making four-minute speeches.

W. T. Magruder: Mr. Chairman, the practice is to put these men in the classroom as students and as observers for two weeks, and also in the laboratories. They are graduates of schools, have practical experience, are twenty-five to thirty years of age, are engineering graduates with several years' experience in motor car work. I think the case Professor Risley mentions must have been an exception.

Professor Risley: I have no intention of diverting the discussion. The point I want to make is whether or not we think it is a good idea for us to be put in some technical place as President Howe has said. What do you think of the proposition that we should offer ourselves to be placed in these positions where we may be technically trained? I have just used guns as an instance.

Professor Magruder: I might add another statement. We have a man at our aviation school who is an expert in gunnery, but being a civilian, he is to be replaced by order from Washington by a young instructor in gunnery. There is a difference between his being an old experienced man in the art of gunnery for many, many years and not wearing a uniform and the man who does wear a uniform.

Professor Risley: Then you mean the government will hold to Army men?

Professor Magruder: Yes.

Professor Risley: I should hold, then, Mr. Chairman, that the idea should still prevail. I am perfectly willing to be called an Army man. I am perfectly willing to have them take me. They can take my youngsters and my cash and they can take me. I think we should be prepared to do the job. I am willing to be an Army man and wear a uniform and do all that the uniform calls for.

REPORT OF THE JOINT COMMITTEE ON ENGINEERING EDUCATION.

BY C. R. MANN.

Mr. Chairman and Gentlemen: Four years ago at the Princeton meeting I first appeared before this Society and discussed the possibilities of a report on engineering education. It is appropriate that the final report on the subject should be presented here at Evanston, because, when appointed to undertake this study, I was at the University of Chicago, and the problem was entirely new to me and outside of my then work. I there made tracks as fast as I could to the nearest source of enlightenment upon this subject—Director Hayford, of Northwestern—and the first formulation of the outlines of this study were made in two long sessions in the director's office upstairs. Along the general lines there discussed, the work has proceeded for the past four years.

I was very much interested last evening to hear Director Hayford's statement of the ideals of this school of engineering. There were two things in his remarks with which I wish to take immediate exception. He stated that the ideal of the engineering college here is the thorough training of the engineer both in science and on the humanistic side so he should be an all around man, capable of carrying on his profession successfully, not only in the two or three years after his graduation, but for the next forty years of his life.

That is an ideal with which we all agree. He stated, however, that the policy of this school was to keep the men here for five years while the policy of the country has turned to an intensive training which is much shorter; and, therefore, he said the ideals of this college had to be held in abeyance for the next few years, but he hoped to revise them after the war. Those last two points are the points on which I do not share

Director Hayford's view. I do not share the view he takes that these ideals are in abeyance in the slightest degree during the war, nor do I agree that it takes five years to develop a man of the type that we all want to see developed. In fact, this crisis in which we now find ourselves is the time when the engineering profession should show the schools how to develop themselves so that they can accomplish the desired result in a very much less time than has usually been supposed to be required. It is perfectly obvious to any one who is familiar with college education that we have never put an adequate amount of steam into our college studies.

The reorganization of education so that the students have more steam,—so that they go to work with the same spirit that they go to football games,—is essentially an engineering problem; and I believe that this association at this time can safely follow the advice given by Mr. Baker last night, and undertake to develop a new type of engineering education which will accomplish the ideals which Mr. Hayford mentioned last night. It is an engineering problem.

You remember Watt's first engine was a ten-horsepower engine. He set it up in a factory at Manchester to test it. A large crowd assembled and Watt himself wrote of the occasion: ''The crowd was enormously impressed with the magnitude of the engine and with the awful noise it made.'' Now that engine consumed ten pounds of coal per horsepower hour. Ten horsepower,—enormous wheels going around with great ostentation and awful noise accompanied the display of the engine. At present in the power plants we see a large round cylinder and hear a gentle hum, and there is five—seven—eight thousand horsepower being developed at one pound of coal per horsepower hour. The conversion from the one to the other has been an engineering problem.

We have an analogous condition in the schools. We are ostentatious, the wheels are going around, there is a great deal of noise; yet too much energy is escaping through the safety valve in shouts and steam on the football field.

The report is now finished. The proof was sent to the committee about the middle of April. There are one hundred and twenty-five pages. After the Joint Committee on Engineering Education had this for about five weeks, they held a meeting in New York on May 24, at which they voted to approve the report as it was with a few minor changes. Those minor changes were incorporated and the document is now ready to be printed. It was, however, felt very desirable to preface the report with a suitable introduction by the committee, stating the history of the movement and giving an explanation of the particular ideas or particular lines of activity which the committee feels the report is well calculated to stimulate. That introduction has been written and is being circulated among the members of the committee. When it is finally approved, a brief introductory note will be written. As soon as these introductions are in proper shape the report will be issued.

It has been arranged that the members of this Society will all receive copies as soon as it is off the press. I am sorry to say it will take some weeks, certainly not later than the first of September, before it will finally be in your hands in finished form.

It has taken so long to prepare this report—four years since I began work—for several reasons. The chief reason is that during these four years the engineering profession has radically changed its own views as to what engineers are for and what their particular problem is. Of course, it was useless to issue a report that would merely describe the situation as it was then and would not point out any direct road of progress that would be useful for the next ten or fifteen years.

In the second place, the report as first written was too long. It would have filled some two hundred and fifty pages of print. Dr. Pritchett felt it was much better to shorten it and make it more direct. Therefore it was rewritten as reported last summer at the meeting in Washington. Since then it has been completely rewritten again and has finally been reduced to one hundred and twenty-five pages, which any one can read in an afternoon and then digest at his leisure.

The report is divided into three parts,—like " All Gaul." The first portion deals with present conditions. It treats of the development of the engineering schools in the United States, their early history and the aims and curricula of the early schools. It shows how Rensselaer, for instance, built up its first curriculum, where it got its money, how the Massachusetts Institute of Technology curriculum was established. It points out the close resemblance between the early curriculum of Massachusetts Institute of Technology and that at Rensselaer, and calls attention to the fact that the Rensselaer curriculum was imported from France. It deals with the struggles for recognition and the obstacles the engineering schools had to overcome because of the failure of the professional engineer to recognize that engineers could be trained in school. Up to that time engineers had been merely trained by the apprenticeship method.

It deals with the changes of curricula from the beginning to the present time and discusses their content and the distribution of time among the various courses. It discusses the methods of administration in engineering schools, faculty control, student elimination and progress. Much of this material has already been presented to this Society as to the percentage of students that are eliminated and the percentage of low grades in various subjects. It then takes up types of instruction in engineering schools, and indicates briefly some of the common practices in teaching the standard or fundamental subjects such as physics, mathematics, chemistry and English. That first part is an attempt to state what present practices and conditions are, and to describe the situation that needs analysis.

The second part tries to analyze this situation into separate distinct problems. It is called " The Problems of Engineering Education." The first chapter deals with the problem of admission,—what the present practices are, how the present practices have developed, what questions are being considered now by the schools in reference to their entrance systems, what experiments are being made,—and it attempts to demonstrate that the development of entrance requirements in the past fifteen years has been away from the control of individual judgment in deciding whether a boy is fit for college or not and toward a system of committee control. The College Entrance Examination Board, as you know, was organized to do away with this individualism in college entrance examinations,—where the professor gave his own examinations and made his own decisions as to whether the boy was fit to go to college or not. This was a step away from reliance upon the personal judgment and bias of individuals and toward entrance tests upon which all individuals will agree; that is, objective tests. In order to indicate how such tests could be developed, and what reliance could be placed on them, a series of experiments were made for the Carnegie Foundation by Professor Thorndike of Columbia University. These experiments are described in the appendix.

The second problem is called " The Time Schedule." Attention is here directed to the fact that the current practice in making curricula is for the faculty to discuss only how much time shall be allotted to each particular subject. As you all know, the Committee on Curricula, or something of that sort, meets, draws up a schedule and says, " We will give five hours a week Freshman year to mathematics, five hours in chemistry, three hours in English, etc.," and having determined the time schedule, they turn this allotment of time over to the department and in general allow each department to do whatever it likes with its time.

So far, little effort has been made to reverse that process and determine what information and ability in mathematics an engineer must have and how much time it takes to train the average of the class to that degree of skill in mathematics; and then to allot that time to the mathematics department. Little progress has yet been made in experimenting,—for a lot of experimenting is necessary to find out the answer to the question: "What mathematics must every engineer have thoroughly mastered and how much time does it take to teach that to a reasonably intelligent youth?"

The content of courses is the next main problem—"What shall we include in the different courses?" This needs no further explanation.

Testing and grading is the next problem. It is here pointed out that current methods of testing and grading in college are like entrance examinations still subject to the fallacies of individual judgment because every department certainly, if not every individual professor, sets its own examination papers and passes its own judgments. Under those conditions a test is apt to measure more how much a student has conformed to certain points of view of the department rather than to measure his real ability in handling the particular subject. So the question is raised: "How shall we conduct testing and grading so as to make it a real test of the student's ability to handle the material they are supposed to handle because of their participation in that course?"

It is pointed out that a real test of ability, which is objective in the sense that everybody must agree to the finding of the test, is an enormous incentive to a student. It releases his energy to achieve the best that is in him. Such a test is everywhere used in athletic work, because if a man runs the hundred yard dash in ten seconds or eleven seconds, whatever it is, everybody can measure the time and determine accurately and objectively whether he has achieved what he should achieve or not.

At present there is very little such testing in college work. If we can devise tests that are real measures of achievement so that the boy feels when he has received "A" or "B," that this measures his real ability, you have in your hands a weapon of enormous power for releasing the boy's energy and aspiration to achievement.

The next main problem is the shop-work. This is analyzed in this way: There are a number of types of shop-work. One general type merely sends the boy out to observe what is going on in shops. That was the original type at Rensselaer back in 1824. It is still carried on in a very effective manner at Yale. There they have ten days in the junior year when the class comes together and is taken through certain shops and shown certain particular operations in practice; then they go back and discuss these and are told about what they are going to see the next day. The next day they see other shops, observe other practices, discuss them and write reports. This practice has a large value. It is very much like the shop excursions to visit industrial plants.

The shop-work that is given at Worcester is of another kind which began with the founding of the Washburn shops back in 1868. The idea here is that it is essential that shop-work have a direct commercial value,—that the boys build something salable, and that the test of the shop-work is its salability in the open market. This is an objective test. The shop-work is still conducted on this basis at Worcester. The boys are given certain exercises to develop skill, and then produce drill-presses and other machines which are sold in the open market. I believe Rose Polytechnic Institute runs its shop on the same basis.

The idea of connecting production with the shop-work and making the production methods an essential part of shop-work has received different treatment at the University of Illinois, where they call the shop a shop laboratory. They manufacture a two-cylinder gas engine in a shop that is organized as if it were a real producing plant. It has its planning department, its specifications for every job and its tool room. The boys take turns in passing from one division to another and thus get experience in all operations of the shop. It is run on a scientific management basis, and incidentally the students get some skill with machinery and tool work by carrying out exercises that are specified in the same detail as would be the case in a regular plant. The idea is to make the shop a laboratory in which to demonstrate to the student how to run a production plant scientifically. The students work with great enthusiasm and there is a real objective test there because the different squads of students are rival teams. They have to get their jobs done in a specified time and they rival one another as on the football field. There is real snap in it.

The other type of shop-work, which is the common one in most of the schools, was started by the Massachusetts Institute of Technology in 1876. President Runkle went to the Centennial Exposition and saw samples of the Russian system of shop-work, in which production was entirely divorced from construction. Production processes were analyzed in the fundamental shop operations of filing, chipping, boring, etc., and each boy was made skilful in each of these operations. Having learned these physical manipulations, he was supposed to get his construction experience after he graduated. That is the type of shop-work that is now found in most of the engineering schools.

There is one other type of shop-work and that is the type at Cincinnati, where the boys spend half of their time in a real shop, doing real production work for real pay, and the other half in school, discussing the problems which they have discovered in the shop. This Cincinnati plan, I find, is usually conceded to be a plan to get familiarity and experience with industrial shop-work and the general prevailing opinion seems to be that it is a very good plan for producing mechanics—high-grade mechanics—but it is not the scheme to be used for developing the type of engineer we all want to see developed.

It is perfectly obvious, of course, that no school has yet achieved the ideal, but the underlying notion in the Cincinnati plan is that real production work,—industrial practice,—is the source of all engineering problems; and, therefore, a man is best trained to solve engineering problems by practice in solving such problems. Hence the student should be taught in the shop to find problems and to bring them out of industry back to the school to be solved theoretically there. This idea has been developed still further at Cincinnati until at present certain of the students in the junior and senior years no longer work in industrial plants at industrial jobs but work in the research laboratories of those plants.

The process of selection on the basis of—''Can the boy see the problem in the physical situation; can he take that problem back and solve it?'' is one that picks out the men who have the research ability. At present a number of the Cincinnati students are working in the Dayton laboratories as research assistants in electrical lines and these are found to make extraordinarily satisfactory research men; so that if the general principle of seeing the problem in industry and carrying it back to the college for solution is emphasized and stuck to without being carried away by the mere manipulation, the Cincinnati plan does enable us to develop and select men of research ability in a novel but thoroughly satisfactory way.

Therefore, the question is raised as to whether this plan of shop-work, where the students spend part of their time in a real industrial plant, there meeting the real problems of industry and thence carrying them back to the school for discussion, does not offer a clew to a fruitful solution of the shop-work problem.

The Massachusetts Institute of Technology has developed in the past year some similar work in the chemical and electrical engineering lines, and a very interesting experiment is now being developed in connection with the Western Electric Company by Professor Wickenden. I hope that Professor Wickenden is here today and that he will tell you what he is planning to do in connection with developing boys at the Western Electric Company and the Massachusetts Institute of Technology along this line.

Please notice I am not passing judgment on the answers to any of these questions. The report doesn't do that at all. It leaves you to decide whether you will try anything different from what you are now doing or whether you will continue in your present practice.

The third part of the report suggests solutions of the problems that have been discussed. It is hard for me to explain these suggested solutions because they are so extensive.

The first chapter deals with the problem of how to construct the curriculum. The report advocates the principle of trying first to determine what abilities an engineer must have in fundamental subjects; that is, what the engineer must be able to do with mathematics, what he must be able to do with his physics, with his chemistry, etc. We must first determine what is the information and what are the abilities that every engineer must have—every engineer! I believe personally it is possible to determine this to a high degree of probability. Having determined this and having made a list of all the things that an engineer must know and must be able to do in mathematics, in chemistry, in physics, in shop-work and in laboratory work, I believe that it is possible to find out on the basis of experience he has already had and with a little experiment, how much time it is going to take to teach an average boy these things and to make him skilful in these things.

Therefore, I suggest that the curriculum consist in the first two years or the first three years (I will leave the time undetermined) of simply the things that every engineer must master. We will have to find out by experiment how long it is going to take to teach these things, for it may take a year and a half, or two, or three years; but there certainly is a common body of information and certain common abilities that are fundamental to all branches of the engineering profession and every boy should get them and get them first.

This information and these abilities cannot be developed, it seems to me, by mere instruction of the type that is now given. That is, if you merely instruct the boy in his mathematics as you now give it for five hours a week and don't make him feel that mathematics is an essential part of surveying and mechanical engineering and everything else the engineer does, his mathematical training is not likely to be so transferable and usable in engineering practice as it is if he feels while he is doing his mathematics that it is a real thing.

In order to accomplish this end there are three phases of engineering work which should be closely correlated and developed together. One is the industrial phase. The student must know something about the problems of engineering as they actually occur in industry and in the world's work. Mind you, I don't say it must be the Cincinnati type of experience; it may be work in industrial plants, it may be the Massachusetts Institute type or some other type, but there must be some school-supervised contact with real engineering work under real conditions. There must also be running parallel with this a certain amount of engineering laboratory work in the school where the young engineer learns to answer the questions that can't be answered in any other way. He finds the problems in industry and brings them back for solution to the school. Some of these problems can be answered by theoretical work only, but others can be answered only by experiments in the laboratory.

The third essential factor in the backbone of the course is the theoretical work in mathematics and science.

Those three elements seem to be essential to the entire course all the way through. We should not set the freshman in to studying only mathematics and theoretical chemistry with abstract scientific laboratory work, modern languages and English. We should not wait until the middle of the second year before giving any of the real engineering experience that seems so essential to close the safety valve and not allow so much energy to escape on the athletic field. In order to get more skill in the engineering work it is necessary that we have in the very beginning of the freshman year engineering laboratory work in parallel with the theoretical, mathematical, physical science work, in order to make the school real to the boy and give him a real enthusiasm for it.

But when you have done this, you still have not answered the question of how you are going to develop the man as a man and what you are going to do for the humanistic side of the engineer.

This question adds a fourth element which seems essential for every engineer through his entire course. This requires a definite course which is planned simply to develop in connection with the engineering work an appreciation of the human relation involved in engineering and the humanistic values he must understand if he is going to be a real man. There are a great many ways in which this can be done, but the type of work which seems most worth trying is the type of work now being done at the Massachusetts Institute by Professor Aydelotte in his English literature designed to give the engineering student what he really wants to know about English literature. Professor Aydelotte begins by asking the boys why they came to college, why they want to be engineers, what an engineer really is, why an engineer is different from a mechanic, if there is any relation between the engineer and the writer of English literature, etc. He discusses those things and gets the students to write themes that are often remarkable. Incidentally the boy also learns to express himself clearly, to write good English and to like good English literature.

This same method can be applied to the study of sociology, the study of economics, and so on, and therefore, the report suggests that we carry along throughout the entire course, occupying possibly a quarter of the man's time, a course of this sort which gives the student some acquaintance with and appreciation of the best things in English literature, philosophy, economics, and human relations generally. This suggestion completes the first part of the curriculum—the part that is common to all branches of engineering, and imparts the information and abilities that every engineer must have.

Throughout the entire course a great deal of attention must be paid to the testing and sorting of the men. Testing and sorting processes were in a very vague state a year or two ago. But an enormous amount of experience is being developed and collected at the present time by the efforts of the War Department to test and sort men for the Army mobilization. The Department now has psychological laboratories for testing all the men in two of the camps. They have personnel officers in all of the camps, and the work is making rapid progress. An enormous amount of information as to the meaning of these tests and their validity in sorting out ability is being gathered and digested and trade tests are being devised to pick out specific ability for certain lines. Before the war is over we will doubtless have some very reliable information as to valid methods of using objective tests and this will be of enormous importance in selecting students for admission to engineering schools and in sorting young men during the first year or two of their course, so as to decide whether a boy ought to go into the civil engineering or some subhead under civil engineering, or into mechanical or electrical engineering. In other words the experiences with the students in their common work that extends over two or three years should be utilized not only to train the man's ability to know and do things, but also as a means of vocational guide to select men and steer them, in the latter part of their course, into the special lines of work for which they are fitted. So the latter part of the course will be made up of large groups of specialties. Those who have been selected by the first two or three years' work as qualified for civil engineering will be put in a group where for the next year or so they will deal first with all the materials of civil engineering not included in the first two years, but which are essential to all the sub-specialties of civil engineering. Then they will proceed from that into some particular specialty.

The next chapter deals with the teachers, and the essential point there is that the teacher is, of course, the crux of the situation; and that the present organization of universities is not well qualified to encourage teachers to experiment and undertake the sort of investigation that is going to be necessary in order to put a plan of this sort into operation. Hence an organization at the school should be made for the purpose of studying the teaching problem, and the school and faculty should recognize at the start that it is some business of the professor of physics what the professor of mathematics is doing; and it is some business of the professor of electrical engineering what the professor of chemistry is doing. We must drop the practice of simply deciding at the faculty meeting how much time these different subjects shall have and take up the practice of discussing what the work of each department shall be.

When this has become recognized practice, the mathematics teacher, if he goes into it in the right spirit, instead of feeling that his interests have been sorely trampled upon when the professor of physics or engineering presumes to tell him what they want done, will find his work in mathematics has become enormously more inspiring to him and to the students. It will engender good feeling of the very best sort and result in a release of creative energy among the whole faculty. This is a cardinal point—that conditions be developed at the schools that will make the teachers want to study their problems together, instead of the present conditions which discourage the undertaking of anything that is not according to Hoyle. Those of us who had the temerity to break away and study education in spite of the present system took our lives in our hands. But yet we have lived till there is prospect we may still see that system develop.

I may say the position which I nominally hold of Professor of Education at Massachusetts Institute is created for the purpose of developing this kind of a study of the teaching problem at the Institute. The work has not yet started because of other more pressing needs, but there is a recognition and a willingness to do this work at the Massachusetts Institute, and it has got to be done in order to develop the teacher and to release his inventive ability and his creative energy so that he can really put his enthusiasm into the problem on which he is working.

The last chapter deals with the professional engineer and its contents has already been presented at numerous meetings. In the opinion of the engineering profession itself, the most important things for the engineer are character and good judgment and efficiency to do things and to understand men. These are first, and then comes his technical knowledge and his technique. Hence the ultimate question is—how are you going to train people so as to develop these personal qualifications while you are giving them the requisite technique and skill and knowledge?

Of course, we all know the function of the school is to turn out men who know things and can do things; and if we can give the other qualifications in addition, well and good; if not, the function of the school is still merely to make men who know and can do.

In this connection it would be well to read two of Hobson's books. One is called "Work and Wealth," and the other is called "Democracy after the War." They are published by The Macmillan Company. The second book has been out only a few months. These books suggest the fundamental conception which seems to lie back of this whole problem; namely, that the underlying question in any undertaking, and the basis upon which an individual makes up his mind as to whether he will do this or that or something else, is the question whether the thing is really worth doing from his point of view. He says to himself, "Is it worth while that I do this rather than that? Is the game worth the candle?" It is on that fundamental issue that the real decision is ultimately made.

The successful men are the men whose conceptions of what is worth while agrees most accurately with the underlying conception of the masses of humanity and who therefore make that judgment most accurately and most correctly. Hence in order to train the engineer to pass judgment on the question—is it worth while?—in a manner that shall be accurate, definite, and as it were inspired, we must train him to appreciate profoundly what humanity considers really worth while. This means, of course, that he has to be well versed in the humanistic side of life, so that the problem resolves itself into the question—"How shall we teach the engineer to understand and appreciate and fight for the things that humanity considers to be most worth while?" It is, you see, the same old problem of education that colleges and universities have been trying for years to solve.

The report suggests that much can be done to this great end by introducing into all of the engineering work and all of the humanistic work a consideration of the question of values and costs. Decision is always reached by weighing,—I am to get this value for this cost; is it worth while? So if we include the appraisement of values and costs, we must not limit the discussion to monetary values and costs. Every engineer knows perfectly well that the decision as to whether to build a bridge or not is based ultimately on the answer to the question—"Is the value of the bridge to the community worth the cost?" A long series of more subtle appraisement of human values must precede the engineer's calculations. It is the power to solve these subtle problems which causes the man who is skillful to make progress and become the great engineer. A great engineer is the man who is subtly powerful in judging the balance of values and costs in the most far-sighted way.

Therefore in order to develop men who can appraise values and costs and make a sound decision, practice in this should be included in all the engineering work. This means that when the student is working at mechanical laboratory work he will be given as a problem to determine whether certain gears should be made out of steel or phosphor-bronze to fill certain conditions and in consideration of the price of the goods and the difficulties of manufacture, etc.

If questions like these are intelligently introduced into all of the engineering and the scientific work, it will do much to answer eventually the engineers' demand that we develop men of character, judgment and so on, along with technical knowledge and skill.

This is the gist of the report as it stands. I regret that it was not possible to issue it to the members of this Society prior to the meeting so you might have had time to look into the details and digest it and thus take part in a real red-hot discussion. I know the engineering schools are going to divide into two camps on this subject, those that are for it and those that are against it. You can't occupy middle ground. You either come all the way across or you stay all the way on the other side.

It is like the present situation in the world's crisis; you can't take the middle ground. As the darky put it in his sermon one morning—"Brethren, the whole world are at war. Nations are scrappin' with one another, and this ain't no time for a nigger to sit on the fence. In the old days when I was a boy they used to make the fences out of rails, and a rail fence was a pretty good thing for a nigger to sit on, but now they make the fences out of barbed wire and this ain't no time for a nigger to sit on the fence."

WOMEN EMPLOYES—PLANO WORKS.

BY F. J. GERNANDT,

Superintendent Plano Plant, International Harvester Corporation.

To us at the Plano Works, West Pullman, it has been an interesting experience. About a year ago we started to put girls to work in our factory. The first job we put them on was to inspect parts for roller bearings. We previously had young men doing this work, sitting at a bench and measuring with micrometers. We needed the men for machine work and thought it was a good time and place to try out girls. We made it known among our men that we wanted a few girls; and if they had daughters, sisters or friends, we would be glad to take their applications. From that time on we have had no trouble getting female help. It will be of interest to you to know that to-day we have a waiting list of 250, all living in this district.

At first, the men were not accustomed to female labor, but in a short time the shop adapted itself to feminine help, and now they seem to treat it as a matter of course. Up to the present girls have not been placed on so-called dangerous tasks, where there is a chance of bodily injury; neither have they been placed where they would be subject to severe heat or cold. We have tried in every case to pick the woman for the job she is to do; and when interviewing applicants who are asking for work, we try, as far as possible, to class them according to age, past experience, type, nationality, health, physique, intelligence, cleanliness, education and general aptitude.

As we never employed women before in the factory and started slowly, it has given us a good opportunity to reëstablish the personal touch between the employes and the office, which so often gets away from us in a large works. I make it my business to go through every department where girls are employed and examine their work, taking a personal interest in their working conditions and earnings; and do not hesitate to show them in every way that we think just as much of them as we do of the men.

On the whole, it is our observation that women are more attentive, show more interest in their work, and are anxious to make good on any job you give them.

A rest room and lounge room has been provided, furnished with chairs, reading table, lounges and magazines of various natures. The girls stop work ten minutes before the men, which prevents the mingling which is often objectionable to the women going out through the halls and stairways during the rush after the whistle blows. It also gives them an opportunity to get on the street cars before they are crowded; although, as I have mentioned, we try to hire mostly from this immediate locality.

It is true that women require more supervision, and the overhead, such as rest rooms, matron, etc., is greater for them than for men, but we feel that it does not overbalance the scale. The matron acts as a bumper between the foreman and subforeman and the women. We do not ask her to exercise any authority whatever in regard to the girls' work. To make myself clear: If a girl does not work as steady as she should, comes in late, or spends too much time in the rest room, we expect the foreman and sub-foreman of the department to discipline the girl. The matron is primarily on the job to look after the girls' welfare. Of course, if the matron thinks the girls are not doing the proper thing, she would call the attention of the foreman and sub-foreman to such cases, but we do not expect her to enforce discipline of any kind. Her function is to get and keep the good will of all the girls and women in the factory; so they will always have someone to go to with their problems, whether they are matters occurring in the factory or in their private life. Our matron tells me that a man can swear, but a woman must have a cry to placate her

In the inspection department they work out well on a class of work where gauges and limits are already determined, and where it is not a case of judgment.

Of the first lot of nine girls that went to work in the inspection department, all are with us at present, with the exception of one, and she left to get married. With few exceptions, they have lost hardly any time this year; and last winter during the severe weather they came to work when many of the men did not. We put the girls into the same room with the men, but at one end. We have no fault to find with the quality or quantity of work they do; and after serving long enough to become proficient, we rate them the same as the previous workers on that particular class of work. Within their limits, which are mainly physically, they can do as much work as previously performed by men. A great many of the jobs performed were formerly done by young men or boys, who grew up with the job or machine and were really in a blind alley. The girls readily learned the use of micrometers and fluid gauges used in this type of work; and it was not long until we had replaced all the men with the exception of a floor inspector, whose duties include the supervision of the women inspectors. The girls are anxious to make good on any work you give them. After a few months of bench work and giving them a chance to become shop-wise, we tried them out on small grinding machines. This was done by boys, and being a steady grind it was hard to hold them down. These machines were in the room and close to where we had the girls on inspection work. The boys were taken off these machines one at a time and girls put in their places. On jobs of this nature they worked out to good advantage. The girls have taken to this work nicely. We have comfortable stools and favorable working conditions, and they earn more than the boys did, simply by sticking to the job. The floor inspector oversees the work and the sub-foreman adjusts and sets up the machines. This was also done for the boys.

The girls, at first, were reluctant to try machine work, but when they found out by experience that they could earn more on a machine than on a bench, we had no trouble to induce them to try machine work. The work is all light and adapts itself nicely to female labor.

We also have girls on packing and counting, running drill presses and a girl timekeeper. While this is not new regarding the employment of women, yet, to us, it is a case of where men did every job previously; and I might say, this same applies to all the other departments.

In the department where we make magnetos there is a great variety of bench and machine work. The girls in this department become very apt and as there are a large variety of pieces and operations, the work is of such a nature that we can change them about often, and place them on such jobs that they are naturally fitted for. In this department, we have girls running lathes, milling machines, punch presses, grinders and drill presses.

In the tractor department there are girls employed at present assembling small parts, packing tool boxes, using soldering irons, riveting, inspecting radiators, etc. These girls can use a hammer about as well as a man, and were put on these jobs with special attention to their strength, although we make it a practice never to require a girl to lift more than twenty-five pounds at one time.

In the paint department girls are doing brush work, stenciling, pasting labels, striping, and in fact, they are doing the work of a man wherever their strength will permit.

In the machine shop, on account of the weight of the material handled, we are placing girls on drill presses only, at this time.

In our chain department, where we make a heavy steel chain for the tractors, we are employing women altogether, with the exception of the trucking and heavy lifting. This is due to the fact that this equipment is all practically automatic, or semi-automatic, and being a late development at this plant, was designed with the idea in view that it would be strictly a department for girls and women, including the janitor work. I might take this occasion to say that on all machines it has been our practice for years to make them as safe as possible and practically fool-proof, and we have had no accidents whatever from girls running a machine. In one instance a girl tried to show another girl how to pick a piece out of a machine and deliberately stuck her finger into a cutter and got a rather severe cut; but in this case the girl was not operating the machine, nor did she have any business showing the other girl what to do or what not to do.

Through the various departments we have girls inspecting. They inspect the various parts before they are assembled, and after they are assembled. In the machine shop they inspect such castings that are not assembled into any particular unit in the department, but go directly to the paint and packing departments. Such castings must all be thoroughly inspected, as there is no opportunity to catch mistakes after they leave the department. The girls and women look these over carefully, trying the gauges if there are any little defects which can be remedied by a little filing or fitting—they take care of these small jobs.

We had quite a number of men as timekeepers and office help, and as they are now leaving we are replacing them by girls. We find no difficulty whatever with the girls acting as timekeepers out in the departments where there is mixed help.

One thing which we are trying to do, is to standardize all clothing for the women in the factory. Overalls, or overettes, are being introduced, and some of the girls are wearing them. We believe that if all the girls are dressed alike, that there will be less rivalry as to dress, and probably less comments as to the matter of dressing. This is the information that the matron gives us.

We have not posted a single rule or regulation pertaining to girls or women which is not already incorporated in our regular factory rules; and about the only hard and fast unwritten rule which we have is: that there be no gossiping or quarreling. I am glad to say that if there has been a case of this nature, the matron has been able to take care of it without bringing it to the front office.

At the present time, especially in our departments where we employ skilled tradesmen, the younger men, where they have been placed in an exempt class of the draft, are leaving us to work in munition factories. As we are unable to get men to fill these positions, we are taking men who are exempt from the draft for various reasons, from the other departments, and placing them on machines and on jobs in the tool room, and training them to become proficient on this particular machine or job by appointing one of the tool room foremen as an instructor; and making it his duty to go from man to man all of the time, simply to teach these men to become proficient operators.

For instance: If we have a man in the machine shop who has been particularly apt on a simple class of lathe work, we take him into the tool room, put him on a lathe and train him to do tool room lathe work. If he turns out to be a good choice we keep him there, and he can eventually earn as much as a skilled lathe operator on tool room work. If, for any reason, he does not turn out suitable for this class of work, we train him in various operations on the lathe, so that we can turn him over to one of the manufacturing departments in which they have difficulty in picking up men accustomed to lathe work, and where the foreman cannot spare the time to instruct the men in the fundamentals.

This is the idea in general which we are carrying out, and we do not leave a machine idle nor a job wait because we are losing skilled men. We have adopted this method as the most practical way of taking care of our own present local conditions.

Eventually, it is my opinion that we will, perhaps, have to set apart a certain section of the shop, put in machinery, and under competent instructors run through various parts of our machine production; and train men and women in this way to keep our work shops full of machine operators and semi-skilled workers; taking such as show exceptional skill and giving them opportunities to develop into skilled operators. This seems to be the only solution under the present difficulties.

DISCUSSION OF THE REPORT OF THE COMMITTEE ON ELECTRICAL ENGINEERING.

August 28, 1918.

To the Society for the Promotion of Engineering Education.

In the July issue of *Electrcial World,* we the undersigned read the articles on "The Special Preparation of Electrical Engineering Students for Military Service" as given by the Committee on Electrical Engineering at the recent meeting of the Society for the Promotion of Engineering Education at Evanston, Ill. This, to our minds, was very interesting and in a way strikes a note of humor, as we are both graduate electrical engineers from two well-known institutions.

Private —— is a graduate of —— and has been in the service of his country four months. Private ——, a graduate of ——, has served nine months. Both of us were assigned to the Ordnance Corps and during our assignments never at any time have had opportunity to apply our engineering training. Recently we were assigned to the Chemical Warfare Service, U. S. A., and stationed at ——. Here too we thought that we would have an opportunity to apply ourselves but we have been placed in the boiler room of power plant No. — serving as coal passers. The men over us are all men of little or no education and even though the work is degrading we can not help but see some humor in it.

The crying need all over the world, both in civilian and army circles, is for technically trained men. The Engineering Corps alone could absorb every engineer now in the service. Schools and colleges are doing their best to establish war courses for engineering students but why are they not used once they enter the service? Applications for transfers to Engineering Units will not be accepted and still the men continue to waste their time and training.

Private —— has completed his course at the Westinghouse Electric Company and was employed until four months ago by the New York and Queens E. L. and P. Co. Private —— has been connected with Henry L. Doherty and Company of New York.

We do not cite our cases as a concrete example of how engineers are not put where they could be of best service, but we can mention more cases we have come across in the service; especially while throwing our time away in southern camps. The committee may see theoretically an advantage in establishing these military courses, but should they trace the graduates after entering the service they will find that results are different.

Now in closing we wish to state that this is a personal letter from two soldiers to a committee which is given national recognition and should our names be divulged it may lead to our court-martial, but even at that we could stand it. Nothing could be worse than a coal passer's place in a boiler room, but we hope that our names will not be given away.

Trusting that this letter will be of some little value to you and to other committees, we remain,

Respectfully yours,
PRIVATE ....
PRIVATE ....

COMMITTEE ON THE STANDARDIZATION OF TECHNICAL NOMENCLATURE.

SYMBOLS APPROVED BY THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

June 28, 1918.

Concept.	*Symbol.*
Acceleration, angular	α (Alpha)
Acceleration due to gravity	g
Acceleration, linear	a
Area	A
Breadth	b
Center of rotation	O
Coefficient of friction	f
Coefficients and constants	C, K
Deflection of beam	y
Depth	d
Diameter	D
Distance passed over	s
Distance of extreme fiber from neutral axis	c
Eccentricity of application of load	e
Efficiency (hydraulic, mechanical, volumetric)	e_h, e_m, e_v
Force	F
Force, moment of	M
Friction, coefficient of	f
Head	H
Height	h
Horsepower	hp.
Hydraulic radius	R_h
Inertia, polar moment of	J
Inertia, rectangular moment of	I
Length	L
Load, eccentricity of application of	e
Mass	m
Modulus of section	Z
Modulus of elasticity, Young's	E
Moment of force	M
Moment of inertia, polar	J
Moment of inertia, rectangular	I
Quantity of liquid flowing	Q
Radius	r
Radius of gyration	k
Reactions	R
Revolutions per unit of time	N
Stress, unit	S
Time	t
Torque	T
Velocity, angular	ω (Omega)
Velocity, linear	v
Volume	V
Weight	W
Young's modulus of elasticity	E

BULLETIN
OF THE
Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

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Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., OCTOBER, 1918 No. 2

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ESSENTIALS IN ENGINEERING EDUCATION.

BY MILO S. KETCHUM,

President, Society for Promotion of Engineering Education.

Engineers and engineering schools have taken a very important part in war activities and have shown the value of technical training. Under the changed conditions due to the war all educational methods and ideals should receive careful scrutiny to see whether or not they fill the needs of the hour. In this brief address the essentials in engineering education will be briefly considered.

Before starting to build a machine or a structure the engineer prepares plans and specifications. If we are to prepare to educate an engineer, we should also have specifications for the finished product. A well-known engineer has given the following definition of a good engineer: ''A good engineer must be of inflexible integrity, sober, truthful, accurate, resolute, discreet, of cool and sound judgment, must have command of his temper, must have courage to resist and repel attempts at intimidation, a firmness that is proof against solicitation, flattery or improper bias of any kind, must take an interest in his work, must be energetic, quick to decide, prompt to act, must be fair and impartial as a judge on the bench, must have experience in his work and in dealing with men, which implies some maturity of years, must have business habits and knowledge of accounts. Men who combine these qualities are not to be picked up every day. Still they can be found. But they are greatly in demand, and when found, they are worth their price; rather they are beyond price, and their value can not be estimated by dollars.'' (Chief Engineer Starling's Report to Mississippi River Commission.) Stated somewhat differently, an engineer must have general training, must have technical training, must have professional experience, must have high moral character, must have a knowledge of men, must have a broad vision, must have administrative and business experience.

While all will agree as to the specifications and requirements of a good engineer, a careful study of the curricula of engineering schools will show that there is a great difference of opinion as to what are the essentials in engineering education in order that students may be given the proper training so that they may, after obtaining sufficient practical experience, become engineers. A brief discussion of the essentials of engineering education by an engineering educator who has for some months been engaged in engineering administration may be of value.

In the beginning it should be remembered the problem is not only to train the student so that after sufficient experience he may become an engineer, but also to make a man out of a boy. The latter is even more important than the former; and every scheme of education must keep in mind the fact that clean living and straight thinking are the essentials of all educational methods. Students come to college from high schools with very different degrees of preparation, varying from the boy from a well-to-do family who has graduated from an English or classical high school to the boy from a workingman's family who has had just sufficient training in a poor high school to enable him to enter. While schools with private endowments may select applicants for admission by a rigid examination, most state universities find it necessary to admit by credentials and then give the freshman a full term in which to show his ability.

The most critical time in the engineering student's career is during the first semester when he is making the change from a high-school student to a college freshman. The freshman has no appreciation of his new duties and responsibilities and requires very careful direction if he is to make the best use of his opportunities. Freshman teachers should be men of mature experience, selected for their ability to interest and enthuse students as well as for their teaching ability. If young teachers must be placed in charge of freshmen they should be engineering graduates selected with reference to their ability to interest and enthuse students. In this connection it should be kept in mind that the harshest judge is always one who has been the shortest time on the bench, and also that the teacher who has but recently graduated is usually too critical of the abilities of others and too proud of his recently acquired knowledge to be placed in charge of freshmen classes.

The courses of engineering schools contain little or no engineering subjects during the first two years, and it is difficult to keep up the student's interest. It has been suggested that the student's interest be aroused by the addition during the first two years of properly selected elementary professional subjects. In the University of Colorado the teachers in mathematics, drawing and English are engineering graduates who have had sufficient engineering experience to be able to show the freshmen and sophomores the direct application of their courses to engineering practice. The instructors in mathematics are not only able to teach mathematics, but know from experience the value of mathematics to the engineer. The student immediately feels that mathematics is not something to be gotten by, but is to be a tool that will help him to solve many knotty problems. The instructor in engineering English has had a large experience in technical writing, and is not only able to teach the students to write, but knows from experience the value of English to the engineer. The success of the departments of engineering mathematics and engineering English, with engineers as teachers, is merely an example of the well-recognized fact that the prime essential for a successful teacher is to know his subject. What right, then, have we to expect a teacher of mathematics or of English who has studied mathematics or English merely to teach others to teach, to successfully teach engineering students who are interested in doing things?

An engineer requires training in pure science so that he may be able to apply scientific laws and principles to the solution of engineering problems, and also in order that he may make researches for himself. It is more important that he be given basic courses in science that will open up the field and that will teach him to use scientific methods in taking up a new line of work, than that he be given extended courses going into the technique of the subject and including a large number of experiments.

Mathematics should be taught concretely and not abstractly. The principal difficulty with students and engineers is to express observed facts and data in mathematical terms preliminary to the mathematical solution of the problem. The student should be taught that mathematics is merely a mill into which data are fed to be turned into a form that will be useful to the engineer. He should also be taught that mathematics and mechanics will never take the place of judgment, but are useful in making experience already gained applicable to new conditions, and also that no mathematical process can give results that are any more accurate than are the data upon which the calculations are based. The student should be given training in graphic calculation in order that he may be able to visualize the problem, and thus prepare the data for the mathematical process. Many problems that are very difficult when solved by algebraic processes are very simple if solved by graphics. Teachers of mathematics in high schools and liberal arts colleges, as a rule, have had no training in graphics, and therefore do not use graphics in mathematical instruction. Many students who have shown very little ability to understand algebraic processes are able to understand the same problems when solved by graphics. The engineer should be able to use algebraic or graphic methods with equal facility. By properly choosing the method, it is possible to save a large amount of time in calculations, or one method may be used in making the original calculations and the second method may be used for check solutions.

Many problems in mechanics that are very difficult to solve by algebraic methods are very easily solved by graphics. The calculation of stresses in a continuous beam of variable cross-section, which is a very difficult problem when solved by algebraic methods, is a very simple problem when solved by graphics. The details of this solution are so simple that they may be understood by a freshman of average ability. Graphic methods are capable of as great accuracy as are algebraic methods, and at the same time, are less liable to large accidental errors or mistakes.

All measurements and data used by the engineer in his calculations are approximate values and the results of calculations are therefore at the best only probable values. There is therefore no subject of mathematics that is of more value to the engineer than that of the theory of probability. The theory of probability has been defined as that line of mathematical reasoning by which one is able to determine by scientific methods a result that would be arrived at by one who has had a very large experience and trained judgment. Many of the laws of mechanics may be derived by applying the laws of the theory of probability, which fact shows the direct connection between mechanics and the theory of probability.

Drawing and surveying should be taught to develop the student rather than to make draftsmen or surveyors. In teaching surveying, better results are obtained by the men working in squads than in large parties, as is the custom in actual pracice. The assigned problems should be designed with the idea of developing the theory of surveying instruments and their application rather than with the end in view of making a surveyor.

In the beginning of engineering schools, the curriculum consisted mainly of languages, mathematics, chemistry, and physics, together with surveying and brief courses in engineering construction. Engineering teachers were for the most part men with little or no engineering experience, and as a result the training in the engineering school did not prove to be of any material benefit aside from the libert arts training. The engineering graduate was not looked on with favor, either by the financial man who employed him, or the practical engineer under whom he worked. There was a constant conflict between engineering theory and engineering practice.

With the advance in pure and applied science, the curriculum of the engineering school has changed from an inferior liberal arts course with a smattering of engineering practice, to a course in applied science with a close and intimate contact with the latest advances in engineering practice. Engineering schools now have fully equipped laboratories in which commercial tests are made of materials and machines. Many engineering teachers have made notable additions to scientific knowledge as applied to engineering construction. The feeling of antagonism between practical engineering and theoretical engineering has disappeared, and engineers and technical schools are now working in very close coöperation. Engineering contractors find that they must needs keep in touch with the laboratory if they are to solve present-day construction problems. The most approved and latest advances in mechanics together with properties of materials are now recognized as essential to engineering construction. There is no longer any conflict between engineering theory and engineering practice. It is now universally recognized that a satisfactory design can only be evolved after all of the theoretical and practical considerations have been taken into account. The engineer is no longer satisfied with rule-of-thumb methods, which were the basis of the art of engineering. The engineering teacher is no longer looked upon as an interesting specimen that must be tolerated and endured, but is now given an honorable position in the engineering profession.

An engineer is a man who not only designs and builds safely, but who designs and constructs a structure or machine that is adapted to the needs, with a cost commensurate with the service rendered. The design of a structure requires not only the knowledge of the properties of materials and the ability to calculate the stresses, but also a knowledge of local conditions and requirements, of economical design, of details of construction, of methods of erection, methods of fabrication, and their effect on cost, and many other matters which limit the design. The most economical structure for any given conditions is the one which will give the greatest service for the least money, quality of service and life of the structure being given the proper consideration. Financial limitations often limit the design and the problem then is to design a structure that will give satisfactory service with the money available.

To design a satisfactory structure when limited by financial considerations is a problem that requires the exercise of the highest possible skill on the part of the engineer. He must be able to select an economical type of structure; he must make an accurate estimate of the loads to be carried by the structure; he must be able to calculate the stresses with accuracy; he must make the details of the design with due reference to ease of obtaining the material, to cost of shop work, and cost of erection.

The successful engineering contractor must be trained not only in applied science but in business methods and in addition have some familiarity with the law. He must not only be able to build well, but must have the initiative to work out any problems in a way that will bring satisfactory results to both his client and to himself.

The successful engineer must not only have a thorough engineering training, but he must be trained to know men. The engineer must not only know how to design or to build, but must be able to impress others with his ability. In administrative positions, the ability to select subordinates is a prime essential. More engineers fail in administrative positions due to their inability to select men than due to any other one thing. As a class, engineers are prone to judge men too much on their technical ability alone, and give too little attention to those qualifications and characteristics in men that make it possible to use technical knowledge. A man with a disagreeable disposition ordinarily has no opportunity to use his technical ability except in a very inferior position. One of the most important advantages gained from technical education is contact with other men and an appreciation of the value of human engineering. Of all the materials with which an engineer has to deal there is no material so difficult to handle and control as human material.

In addition to the usual courses in mathematics, mechanics, science and languages, the engineering course should include training, either formally or informally, in ethics and in a man's relations to his fellows. A well-balanced engineering course must not only give training in technical and humanizing subjects, but must give training in straight, logical thinking. The engineering student must be impressed with the idea that in the end he must appeal to the good sense and intellect of his hearer if he is to be able to put his plans into execution.

Methods of teaching students in the class-room and the laboratory are directly applicable to engineering construction. The inspector on concrete construction should instruct the foremen and workmen so that they will understand the effect of a poorly graded aggregate, the effect of too much water, and other details that determine the quality of concrete, rather than undertake to control the work by the force of his authority. The improved methods of construction proposed by the engineer must stand the criticism of the superintendent or the foremen if they are to be effective. A large engineering project is in effect a large engineering school in which the engineer and his assistants are the faculty, the superintendents and foremen are their assistants, and the workmen are the students. The more effective the work of the teacher and his assistants, the better will be the results. Where the workmen as well as the foremen are kept interested in the work, the results are sure to be satisfactory. Interested workmen means efficient workmen. On large construction projects the organization is necessarily so complicated that the workman is easily lost sight of. If workmen are to be efficient, they must be well housed and well fed, and be given adequate opportunities for recreation. The workmen must have sanitary quarters and be given adequate medical attention. The success of engineering construction depends so much upon the character and quality of the service rendered by the workmen, that the engineer in responsible charge should have had considerable training and experience along the line of welfare work and sanitation.

With small construction jobs, it was possible for the superintendent with a limited personnel to accomplish satisfactory results without organization through his own personality. With large engineering projects, where the work must be completed in a very short time, the problem is a very difficult one. The main error in the organization of very large projects is that the administrative machinery is gathered together very rapidly without proper coördination. The problem of harmonizing the different elements in an organization of this character and working it into a single unit is one that appeals especially to an engineering administrator. The problem is one of education and not one in which the results can be obtained by exerting authority. The administrator should have absolute authority in order that he may not find it necessary to use the authority.

The results accomplished in military training camps show that educational methods have been very wasteful and inefficient. The idea that the student's initiative can be developed by turning him loose in the laboratory, the drawing room or the field to work out the problem without instructions is no longer tenable. No man has a right to have initiative until he has knowledge. If the student is taught to think straight and that all work must be planned in advance, he will in due time develop initiative.

The efficiency of engineering education can be greatly increased by the use of proper pedagogical methods. The subject-matter of each course should be selected with the idea of developing the subject in a logical manner. The course should be developed with full notes and definite instructions for all experiments or problems. The most direct method in learning is to study a similar problem that is fully worked out, or to follow a problem survey that is fully worked out with notes or calculations. The use of sample problems, field notes or laboratory experiments, not only assists the student in learning the particular matter in hand, but gives him training in keeping his notes in an orderly manner and shows him that the best results from subordinates can only be obtained when they are given very carefully prepared and definite instructions.

The problems assigned to students should not be too complex or too complicated, but each problem should be selected to bring out and illustrate a few or even one important principle. Better results in teaching topographic surveying can be obtained by giving the student a series of field problems illustrating the different divisions of a survey, than to have the student assist in a large topographic survey where he has only a limited responsibility. All problems or exercises should as far as possible require that the entire solution be carried through by each student independently. The old saying that "a boy is a boy, two boys is a half a boy, and three boys is no boy at all" is almost literally true when applied to students.

In all calculations, experiments and field work great care should be used to impress the student with the great importance of the use of consistent accuracy. The student should be shown that all data which the engineer uses are approximate, and that the results of his calculations are therefore only probable values. He should be shown where he may use a slide rule, where he should use five-place logarithms, and where seven-place logarithms. It will also be useful to show that six-place logarithms require more work in their use than do five-place logarithms with no gain in accuracy. The student should also be taught to use the different calculating machines. While the slide rule is a very useful tool its constant use by the student is open to question, for the reason that he does not get adequate training in performing ordinary arithmetical calculations. The engineer should be able to run hurriedly over calculations performing all arithmetical operations by short cuts or approximate methods, in order that he may be certain that the result is consistent. A common error with students and young engineers is to point off incorrectly, or to work out the details of one column of a tower and then forget to multiply by four.

In teaching engineering design it is very important that the student be given careful instructions. The size of the sheet and the scale of the drawing should be selected so that satisfactory results may be obtained. The time occupied in preparing a drawing of a particular machine or structure varies almost directly as the area of the drawing. Careful tests have shown that in teaching structural design a size of plate of 18 inches by 24 inches is much more economical of the student's time than a plate 24 inches by 36 inches. It should also be noted that the scale of the drawing on the smaller plate is seven tenths of the scale of the drawing on the larger plate. There is an additional saving of time in finishing drawings in pencil. By the use of drawing plates 18 inches by 24 inches in place of plates 24 inches by 36 inches, and by finishing drawings in pencil, the work in structural design in a given course may easily be doubled. While the recent graduate should have some familiarity with tracing, it is very much more important that he be able to make a good pencil drawing.

The student should be given an opportunity to get a familiarity with good literature so that he may in time become a well-read man. This may be done by regular courses or by means of supplementary reading courses. The idea that certain courses were humanistic and therefore liberal, and that other courses were materialistic and therefore not giving a liberal training is no longer tenable. The humanizing and liberalizing value of any subject is in the teacher and is not in the subject. The most important part of any institution of learning is the teacher. The engineering teacher should be a man that will fill the specifications prepared by Engineer Starling in his report to the Mississippi River Commission, and in addition he should have teaching experience and a love for his work. While teachers of this type are worth the price, it is at present very difficult to obtain sufficient funds to keep able teachers from going into practice.

The most critical problem in engineering education to-day is to obtain a sufficient number of competent teachers. The Society can undertake no greater task than to improve the conditions and increase the emoluments of engineering teachers so that engineering students may all have instruction under men of thorough training in theory and practice who can comply with the specifications for a good engineer.

STUDENT ARMY TRAINING CORPS.

WAR DEPARTMENT.

COMMITTEE ON EDUCATION AND SPECIAL TRAINING.

Special Bulletin on Programs in Engineering.

The programs here presented are not prescribed, but are examples of what will be approved. They are intended to indicate how existing programs may be modified by eliminations and condensations so as to meet the needs of the present emergency. Each program covers eight terms of twelve weeks, but it must not be inferred that every student entering on such a course will be kept at college until he completes it. The time that he will be permitted to pursue the course will depend on the needs of the service and the academic record of the student. In addition to the instruction indicated in these courses, eleven hours per week of military instruction are prescribed for the first two terms of the program, and six hours per week for the remainder of the program. The total time to be devoted to military and academic instruction, including examinations, lectures, recitations, laboratory work and supervised study, is 53 hours per week. The hours set forth in the programs attached represent the total time devoted each week to the subject named. The relation of the time given to study to that assigned to lectures, recitations and laboratory work varies considerably with the nature of the subject, but on the average the former is not more than half of the total time allotted. The subject, War Issues, which must be combined with English Composition, is, with the exceptions indicated in Section 26 of the Regulations of the S. A. T. C., prescribed for two terms with nine hours per week for lectures, recitations and study.

It is suggested that as far as practicable students in the Naval Section of the Students Army Training Corps follow an approved course in Mechanical Engineering. Steam and gas engine subjects are necessary for students who attempt to qualify for the Navy engineering schools.

CIVIL ENGINEERING.

First Term.

	Hours per Week.
Mathematics	12
Chemistry	12
*Drawing and descriptive geometry or surveying	9
War issues and English composition	9

Second Term.

	Hours per Week.
Mathematics	12
Chemistry	12
*Drawing and descriptive geometry or surveying	9
War issues and English composition	9

Third Term.

Mathematics	12
Physics	14
Mechanism and applied mechanics	15
*Drawing and descriptive geometry or surveying	6

Fourth Term.

Mathematics	9
Physics	14
Mechanics	15
*Surveying or drawing	9

Fifth Term.

Theory of structures	6
Materials	10
Railroad engineering (including drafting and fieldwork)	15
Highway engineering	6
Map reading and topographical drawing	2
Geology	8

Sixth Term.

Theory of structures	9
Bridge design	4
Railroad engineering (including drafting)	9
Hydraulics	13
Electrical engineering	12

Seventh Term.

Theory of structures	12
Bridge design	10
Railroad engineering	4
Heat engineering	12
Hydraulic and sanitary engineering	9

Eighth Term.

Theory of structures	12
Hydraulic and sanitary engineering and design	16
Heat engineering	9
Railroad design	3
Sanitary science and public health	1
Business law and accounting	6

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* These courses will be divided between surveying and drawing in accordance with the season of year in which they come and the number of students registered. The total time allotment to surveying is equivalent to twelve hours per week for one term.

Mechanical Engineering.

First Term.

	Hours per Week.
Mathematics	12
Drawing and descriptive geometry	9
Chemistry	12
War issues and English composition	9

Second Term.

Mechanism	9
Mathematics	12
Chemistry	12
War issues and English composition	9

Third Term.

Mechanism and mechanical engineering drawing	10
Mathematics	12
Physics	14
Shopwork	4
Surveying, map reading, and topographical drawing	7

Fourth Term.

	Hours per Week.
Applied mechanics	12
Mathematics	12
Mechanical engineering drawing	5
Physics	14
Shopwork	4

Fifth Term.

Heat engineering and English laboratory	15
Electrical engineering	10
Applied mechanics	12
Machine drawing	6
Shopwork	4

Sixth Term.

Heat engineering and English laboratory	15
Hydraulics	11
Applied mechanics	10
Electrical engineering laboratory	7
Shopwork	4

Seventh Term.

Materials of engineering and testing materials laboratory	12
Mechanism of machines	5
Machine design	10
Applied mechanics	10
Refrigeration	2
Engineering laboratory	4
Shopwork	4

Eighth Term.

Power plant design	8
Industrial plants (including heating and ventilation)	16
Mechanics of engineering	7
Engineering laboratory	10
Gas motors or heat treatment	5
Shopwork	4

* These courses will be divided between surveying and drawing in accordance with the season of year in which they come and the number of students registered. The total time allotment to surveying is equivalent to twelve hours per week for one term.

STUDENT ARMY TRAINING CORPS.

ELECTRICAL ENGINEERING.

First Term.

	Hours per Week.
Mathematics	12
Drawing and descriptive geometry	9
Chemistry	12
War issues and English composition	9

Second Term.

Mathematics	12
Chemistry	12
Drawing and descriptive geometry	9
War issues and English composition	9

Third Term.

Mathematics	12
Physics	14
Mechanism and applied mechanics	12
Mechanical engineering drawing	9

Fourth Term.

Mathematics	12
Physics	14
Elements of electrical engineering	2
Applied mechanics	12
Surveying, map reading, and topographical drawing	7

Fifth Term.

	Hours per Week.
Elements of electrical engineering and direct current machinery	15
Electrical engineering laboratory	8
Heat engineering	9
Materials of engineering	6
Shopwork	9

Sixth Term.

Variable and alternating currents	12
Electrical engineering laboratory	12
Heat engineering	9
Mechanical engineering laboratory	8
Structures of machine design	6

Seventh Term.

Alternating current machinery	9
Electrical engineering laboratory	8
Hydraulics	9
Electrical transmission (power and telephone)	15

Eighth Term.

Alternating current machinery	19
Electrical engineering laboratory	6
Power stations (steam and hydro-electric)	13
Motor applications, lighting and storage batteries	15
Business law and accounting	4

COMMITTEE ON EDUCATION AND SPECIAL TRAINING,
By R. C. MACLAURIN,
Educational Director, Collegiate Section.

September 19, 1918.

THE COMMONWEALTH EDISON COMPANY'S PLAN FOR RECRUITING ENGINEERS.

BY W. L. ABBOTT,

Chief Operating Engineer.

The Commonwealth Edison Company, like all other large employing companies, is beginning to be greatly concerned regarding several things which are the outgrowth of the war. Among other things are the scarcity of labor and the scarcity of engineers.

We have, for a number of years, been resorting to artificial means to maintain a sufficient quota of young engineers for our company. In the good old days, the young man from an engineering college would be hired for two dollars a day and put to work in the gang. If he stayed for any length of time, it was not because of any attention we had given him. For a time engineering graduates gladly came to us on these terms, but later on, we noticed they did not come so eagerly as they formerly did, and those we got would stay only so long as they were being given interesting work in which they were learning something. This scarcity of engineers, or their reluctance to come to us, was a progressive feature, noticeable at first with men from eastern universities and technical schools and gradually extending to the men from the universities of the central West. After graduates from these two localities began to find better employment elsewhere, we still got a supply from universities in the South and from those west of the Mississippi River. These men we trained for positions as switchboard operators in power houses and sub-stations, which positions they were glad to take, when other technical men would not consider them, but finally, when men from these last-mentioned sources were getting scarce, and we realized we were no longer getting the best material, our company in connection with some other public-service companies started an educational department, which we called "The Central Station Institute." This institute was a combination of a post-graduate course with a system of practical training in the various departments of the companies. Originally it was intended to secure and train young men for positions as sales engineers and business solicitors. In an eleven-months course, they were given a few weeks experience in each of several departments of the company and finally were located in the contract department to learn the details of the work required of them there and developed into salesmen. Later this program was enlarged so as to include the training of men for the engineering and operating departments. Half of each day was spent in the classroom and the other half working in the department to which the student was assigned. They were charged a tuition fee of $100 for the course, but were allowed $40 a month for the work they did.

This course was quite popular and successful for a time. About eighty-five students graduated in it during the four years which it ran, and up to a year and a half ago about half of them still remained with the supporting companies. They were for the most part superior men and promising material for positions as department heads, but with the outbreak of the war, nearly all of them packed up their old kit bags and went away into the army and navy, practically terminating the experiment.

After the entry of this country into the war, it was found, not only advisable, but necessary, to materially change the course. The work was divided into five periods of three months each, the first two periods of which could be done during vacation time between school years. Instead of five half days each week being spent in the classroom, the new course provided for but one half-day classroom work a week, and instead of being paid $40 a month, the new rates range from $60 to $90 a month. As before the men are shifted around from one department to another, staying not long enough in any department to become of much benefit there and not long enough to carry away very clear ideas of the details of the work of the department. It is believed, however, that after a student has been around in this way for a year or more, he will have a comprehensive general idea of how business is transacted in large corporations, how the different departments coördinate their work, and the relative magnitude and importance of each. This in general is the method which we are using to attract and to interest technical students. In normal times, with a less desirable course, we had to place a limit to the number we would admit to the course, but at the present time, we have less than twenty such students. Under the old course we paid them half as much and got twice as many.

I believe a sufficient time has elapsed so that I can now confess my lamentable ignorance of most things practical relative to mechanical engineering at the time of my graduation, and I have a keen realization of what a great benefit it would have been to me, if at the end of my sophomore year I had secured a job in a power house and had been put through boilers, turbines, auxiliaries and switchboard equipment, had such things been in existence in those days. I would have had a much clearer idea of the things that I wanted to study about.

This plan is working so well that it suggests the advisability of not waiting until the end of the sophomore year before starting this practical training. The cadet might be taken in at the end of his freshman year or even during his high school. A young man who has spent three months of the year for four to six years in the various departments of a large company will come near knowing what the company is made of and he would, after graduation, be already equipped for a very satisfactory position.

I mentioned that eighty per cent. of the graduates of this course left us at the beginning of the war to go into the army or other military occupations. All together, one thousand men have gone from our company and many of them are engineers. We view with alarm, to use that expression, the situation which will exist at the end of another year or two of war should this condition keep up. Not only have our old men gone, but we are not getting new ones. The very men that we want the government is combing the technical schools to get.

We believe that a serious mistake is being made in allowing our engineering students to quit their work and go into the army, particularly where they are going into what you might call non-technical positions. This is true not only of the upper classes, but of the lower classes as well. If the young men who left their classrooms a year and a half ago had then been compelled to go back to school and finish the year and come back this year and finish this year's work, the country would have had hundreds or thousands more engineers available now than it has. We cannot predict the duration of the war, but the longer it runs the more serious the situation will become, and unless some steps are taken to take care of this deficiency, we will have a very serious situation.

Various schemes have been proposed for maintaining the supply of engineering students, and out of it all I sincerely hope that something will come. You doubtless are familiar with the experience of Great Britain at the outbreak of the war in regard to their medical students who quit their medical courses and volunteered as soldiers in the first rush. Naturally, many of them were killed, and after a few months the authorities realized what a serious mistake had been made. They took the remaining students out of the army and sent them back to their schools. It may be that some such action on the part of this government in reference to the engineering students would be advisable at this time.

EFFECT OF THE WAR ON ENGINEERING GRADUATES AND THE INDUSTRIES.

BY G. F. PFEIF,

General Electric Co.

The war has emphasized the extent that our present civilization and its maintenance are dependent on the engineering graduate. We have all accepted modern conveniences without much thought of the engineering skill involved in their production, but modern warfare, with its airplanes, submarines, heavy artillery and other destructive agencies, has shown clearly the need and value of technical training.

When it became evident that our country would take an active part in the war, the first call came for suitable men for training as officers. It was soon demonstrated that men with technical training could readily grasp the fundamentals and principles necessary for the development of a civilian army. Similar conditions existed in the Navy, to a lesser extent, and the expansion of this branch of the service required trained men for the operation of modern equipment on battleships, destroyers and submarines.

Engineering graduates left the industries by the hundreds to take up such work. Others have taken positions in other branches of the service; such as Ordnance, Inspection, Aviation and Signal Corps and to-day the demand is greater than the supply. Almost all of the class of nineteen-seventeen in the engineering colleges have been absorbed and the various engineering organizations have been depleted to such an extent that their efficiency is threatened. It seems that the supply of technical men in the country has been drained during the first year of the war and no adequate provisions have been made for the future. Should the war be of short duration this would not be a matter of prime importance but, on the other hand, if the war is to continue for a considerable number of years, the situation must receive intelligent and far-sighted consideration.

Our engineering industries are confronted with the big problem of furnishing equipment and munitions, and this has resulted in the building of new munition plants of all kinds, ship-yards, power houses, textile mills, etc., all requiring engineering skill for rapid construction and efficient operation. Hundreds of ships are under construction requiring engineers for the design, supervision of construction, installation of equipment and operation. The manufacture of war materials has added many problems to the work of established organizations. The production of munitions, the reduction of importations and increased demand have created a scarcity of various materials. The engineer has had to produce substitutes which would be equivalent or devise new methods of construction. Speed is essential and in the electrical field the application of the steam turbine and electric motors to ship propulsion, the development of the wireless telephone, the production of searchlights, signal corps apparatus and submarine equipment and detectors have added to the duties of the engineer. Many of the parts are given their first trial under operating conditions, adding to the responsibility and increasing the necessity for accurate work.

Prior to our entrance in the war, it was said that the enemy was superior in engineering skill but subsequent events have shown that it was superior organization. We should, therefore, establish closer coöperation among our engineers. In many cases, men in professional life have offered their services, either partially or entirely, but we have a great amount of engineering talent, especially in the technical colleges, which has not been utilized. These men are anxious to help and can render useful services if called upon by the government or by the industries in a consulting capacity or for the solution of special problems.

It is easy to train men for various shop operations involving the use of a single machine tool and the production of standard parts but it has been demonstrated that men cannot be trained for technical work in a shorter time than it takes in the technical colleges. The loss of many men has made it necessary to increase the executive work of the engineers remaining in the industries and girls, or men outside of the draft, have been supplied for calculating and elementary work. However, the engineering college must be given more recognition if we are to have enough engineers to win the war and hold our place in the industrial world in the future.

To this effect, the following suggestions are offered as a possible basis of improvement:

1. Professors and instructors, teaching engineering subjects, should be given deferred classification on the same basis as other occupations.
2. All students whose work is satisfactory should be allowed to remain in college until graduation.
3. All graduates should be assigned to engineering work, either in the service or in the industries.
4. Promising high-school boys should be encouraged to enter college and, if necessary, a part of their tuition should be paid. These boys could be selected from scholastic records or by competitive examination. This should receive special attention in view of proposed changes in the draft.
5. Engineering graduates, enlisted or drafted as privates, should be transferred to technical work. The present system of classification does not seem to be entirely adequate in this respect, as a number of recent graduates are in service which does not utilize their training. Such cases should be called to the attention of the various sections of the War Department which are in need of technical men.
6. Recognition should be given engineers of draft age who remain in industrial work. These men are rendering valuable service but are often judged as slackers by people who cannot recognize service without a uniform.

The engineer has not taken the part in political life to which he is entitled and, until recently, has not had sufficient representation in the councils which have formulated present policies. As a result, there is a feeling that there is no scarcity of engineering material and no danger of a shortage after the war. In the industrial world, the shortage is acute at the present time and the continued expansion of the army and navy will increase the difficulty of obtaining technical men. Every effort should, therefore, be made to maintain a normal number of students. They will be needed, not only for military work and the production of war material but for the production of the ordinary necessities of business after the war. The cost of labor has increased to such an extent that the highest grade of engineering skill and manufacturing efficiency will be needed if we are to compete with the cheaper labor of Europe and the Far East.

Any concerted action by the various engineering societies which would tend to improve existing conditions will meet with the coöperation of the industries.

EDITORIAL.

The Reconstruction Period in Education.—The problem of education, like other problems which have been raised by the entrance of the United States into the war, have been, or are in process of being solved through the various governmental agencies which have been created for this purpose.

The President and Congress are now at work on the various problems of reconstruction which will follow the war. These problems in so far as they deal with education are the types of problems with which this Society should deal. It was recently said to the writer by an Army officer that the war had resolved itself into a question of efficient teaching. If this is true in war times it is certainly true in times of peace, and we may look to see education, especially that which deals with engineering, much modified and enlarged as a result of the war.

Such problems as expansion of industrial research; its relation to colleges of engineering; the development of men for research both in and outside of the institutions; the relation of the teaching staff to industrial development both as regards position of teachers who do consulting work and teachers who do research work; the more thorough organization of teaching with the resulting increase in efficiency which will be brought about through the present organization; all these questions must be dealt with and the answer secured at least in part at the earliest possible time. For instance, it has been the policy of this country in general to say that good teachers must be good investigators. Many disagree with that although we know that the research work adds much to the enthusiasm of the teacher. On the other hand, have we given sufficient attention to the proper organization of teaching to be able to speak with any degree of authority in regard to this matter? The forthcoming meeting of this Society at Boston on December 6–7 will give us an opportunity to hear representatives of Great Britain who have solved some of these questions.

SPECIAL MEETING OF THE SOCIETY TO DISCUSS TECHNICAL EDUCATION WITH THE BRITISH MISSION.

The following letter was received by the Secretary from Dean Henry V. Ames, chairman of the Committee of the American Educational Council:

"At a meeting of the special Committee of the American Council on Education on the Reception of the British Educational Mission to the United States which was held yesterday, the desirability of a meeting of the Society for the Promotion of Engineering Education, to be held probably at the Massachusetts Institute of Technology on December 6 and 7, to discuss with the members of the British Mission technical education in the United States, was considered. The committee felt that in case the proposal for holding a meeting, probably at Harvard University on December 4 and 5, of the Association of American Universities and possibly also of the National Association of State Universities to meet with the British Mission, which is now likely to be arranged—it would be desirable to hold in conjunction therewith a further conference with representatives of technical schools to discuss such topics as: (1) The Liberal Element in Technical Education, (2) The Effect of the War on Technical Education in Great Britain and America, (3) The Organization of Technical Education in the United States. President MacLaurin has offered in behalf of the Massachusetts Institute of Technology to act as host in case such a meeting can be arranged to be held there.

"It is not yet definitely determined that the National Association of State Universities will be able to change the date and place of their meeting to unite with the Association of American Universities. Neither is it definitely determined that Harvard University will be the place for the joint meeting, should there be a joint meeting. It is, however, probable that Harvard will be the place and December 4 and 5 the dates of the meeting for the discussion of topics relating to higher education of a non-technical character.

"In behalf of the Committee on the Reception of the British Educational Mission, I am writing to inquire whether the suggested arrangement would seem to you to be feasible and whether your Society is prepared to coöperate."

The council voted 38 in favor of holding the meeting and 2 opposed. The following suggestions were contained on the cards received from council:

"Would suggest meeting of council instead of general meeting or one representative from each college."

"If the British Mission is not large would suggest in place of below proposed, a meeting of the council with the mission and the expense of a full meeting and the time required from our War Councils would be too great unless it could be in the interval between quarters, December 21 to 30 and in the middle of the country."

PRELIMINARY PROGRAM OF SPECIAL MEETING OF THE BRITISH EDUCATIONAL MISSION TO THE UNITED STATES AND THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS., DECEMBER 6–7.

Friday, December 6. Opening session 2 P. M., President John F. Hayford, presiding.

Address of Welcome on Behalf of the Massachusetts Institute of Technology. R. C. MacLaurin, President, Massachusetts Institute of Technology.

Address of Welcome on Behalf of the Society for the Promotion of Engineering Education. John F. Hayford,

President, Society for the Promotion of Engineering Education.

Response to Addresses of Welcome. British Educational Mission to the United States.

The Organization of Engineering Education in Great Britain. British Educational Mission to the United States.

The Organization of Engineering Education in the United States. Charles S. Howe, President, Case School of Applied Science, Cleveland, O.

Discussion.

Saturday, December 7, 10:00 A. M., Morning session, President Hayford, presiding.

The Effect of the War in Engineering Education in Great Britain. British Educational Mission to the United States.

The Effect of the War on Engineering Education in the United States. M. E. Cooley, Dean, School of Engineering, University of Michigan.

Discussion.

12:30 P. M. Luncheon.

2:00 P. M. Afternoon session, President Hayford, presiding.

The Liberal Element in Engineering Education. British Educational Mission to the United States.

The Liberal Element in Engineering Education. George F. Swain, Professor, Civil Engineering, Harvard University.

Discussion.

Adjournment.

NOTE.—*Owing to the inability of Prof. M. E. Cooley to attend, the subject "The Effect of the War on Engineering Education in the United States" will be handled by Dr. C. R. Mann, Massachusetts Institute of Technology, Cambridge, Mass.*

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor.*

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX   LANCASTER, PA., NOVEMBER, 1918   No. 3

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THEORY OF FRICTION OF V-THREADS.

BY BENJAMIN F. GROAT,

Pittsburgh, Pa.

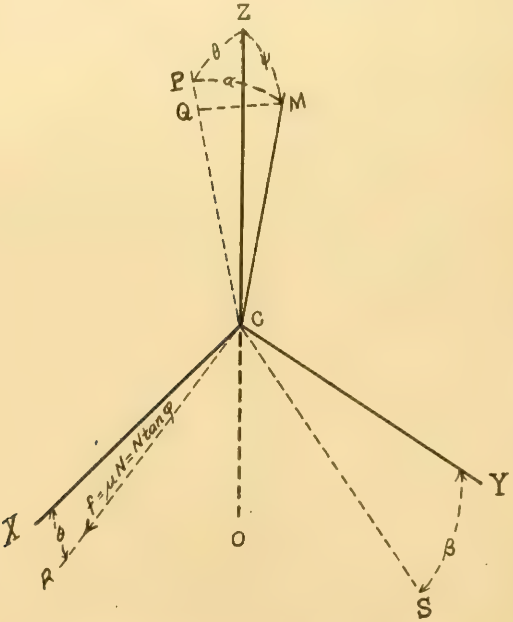
In compiling a paper on the efficiency of the screw,* the author observed that numerous writers have employed the angle β erroneously in the formula for the efficiency of V-threads, β being the angle of slope of the surface of the thread in an axial plane. It was commonly stated that in such cases the friction is increased in the ratio sec $\beta:1$, whereas, it should have been stated that the ratio is sec $\alpha:1$, if α is the angle between the normal to the axis of the screw through the point of application of the resultant of forces and a plane tangent to the surface of the thread at the same point.

---

* "Efficiency of the Screw," Proceedings of the Engineers' Society of Western Pennsylvania for June, 1918.

This angle is not the same as β and the error may make important differences in calculated efficiencies. Suppose, for example, that $\beta=30°$, and that the angle of pitch $=60°$. Then it may be shown that

$$\left.\frac{\sec\alpha}{\sec\beta}=0.9\right]\begin{array}{r}\text{pitch}=60°\\ \beta=30°\end{array}$$



and that if the pitch is changed to 45°, the ratio is increased only to 0.936, either of which errors in design calculations might be material.

In the accompanying figure take the origin, *C*, of rectangular coördinates of three dimensions at the point *C*, on the face of the "V"-thread at which the resultant of forces is supposed to act. Let the yz-plane be an axial plane of the screw so that the xz-plane is parallel to the axis of the screw and contains the line of action, RC, of the friction along the surface of the thread. If ϕ is the angle of friction and N the normal pressure, the friction is $f = \mu N$, where $\mu = \tan\phi$, the coefficient of friction.

Let θ be the angle of thread slope, which is measured by the angle, θ, in the xz-plane between the x-axis and the trace, RC, of the tangent plane at the origin upon the xz-plane. Similarly the angle, β, is the half angle of the thread and is measured by the angle, β, between the y-axis and the trace, SC, of the tangent plane at the origin upon the yz-plane.

Let ψ be the angle between the normal, CM, to the tangent plane at the origin and the z-axis. Then the normal pressure, N, acts along this normal and its direction cosines will be, l, m, n, yet to be found in terms of the slope θ and thread angle β.

The following table of direction cosines, L, M, N, may then be compiled and the conditions for determining l, m, n, also follow:

Direction Cosines.

	L	M	N
Normal, CM:	l	m	n
Friction line, RC:	$\cos\theta$	0	$\cos(\pi/2+\theta) = -\sin\theta$
Thread line, SC:	0	$\cos\beta$	$-\sin\beta$

Equations:

Cosine relation: $l^2 + m^2 + n^2 = 1$

$RC \perp CM$: $l\cos\theta + 0 - n\sin\theta = 0$

$SC \perp CM$: $0 + m\cos\beta - n\sin\beta = 0$

Thus $$\frac{l}{n} = \tan\theta \text{ and } \frac{m}{n} = \tan\beta,$$

from which,

$$l^2 = \frac{\tan^2\theta}{\tan^2\theta + \sec^2\beta},$$

$$m^2 = \frac{\tan^2\beta}{\tan^2\theta + \sec^2\beta},$$

$$n^2 = \frac{1}{\tan^2\theta + \sec^2\beta}.$$

If there were no friction the relations between the thrust, T, normal pressure, N, and turning moment, M_t, upon the screw would be:

$$\text{Thrust,} \quad T = nN,$$

$$\text{Moment,} \quad M_t = lN \cdot r = \frac{l}{n} Tr,$$

where r is the radius, or distance from the point, C, perpendicularly upon the axis of the screw.

With friction, the corresponding relations become:

$$\text{Thrust,} \quad T = nN - \mu N \sin\theta,$$

$$\text{Moment,} \quad M_s = lNr + \mu N \cos\theta \cdot r,$$

$$= \frac{l + \mu\cos\theta}{n - \mu\sin\theta} Tr.$$

Therefore the efficiency is:

$$\eta = \frac{M_t}{M_s} = \frac{\frac{l}{n}}{\frac{\frac{l}{n} + \mu\frac{\cos\theta}{n}}{1 - \mu\frac{\cos\theta}{n}\tan\theta}} = \frac{\tan\theta}{\frac{\tan 6 + \tan\phi'}{1 - \tan\theta\tan\phi'}}$$

or,

$$\eta = \frac{M_t}{M_s} = \frac{\tan\theta}{\tan(\theta + \phi')}$$

if $\mu\dfrac{\cos\theta}{n}$ be changed to $\tan\phi'$.

Now $\cos\theta \div n = \cos\theta\sqrt{\tan^2\theta + \sec^2\beta}$,
so that

$$\mu' = \tan\phi' = \mu\sqrt{\sin^2\theta + \frac{\cos^2\theta}{\cos^2\beta}}$$

$$= \mu\sec\beta\sqrt{1 - (\sin\theta\sin\beta)^2}$$

is an equivalent coefficient of friction which may be substituted in the formula for square threads to determine the efficiency for "V"-threads, since $M_t \div M_s = \tan\theta \div \tan(\theta + \phi)$ is the formula for square threads when $\mu = \tan\phi$ is the coefficient of friction.

Observe that

$$\mu' > \mu \text{ since } \sqrt{\sin^2\theta + \frac{\cos^2\theta}{\cos^2\beta}} > 1,$$

by the nature of the functions under the radical.

To show that the factor by which μ must be multiplied to obtain μ' is equal to sec α, where α is the angle between the tangent plane at the point C and the normal from C upon the axis of the screw, notice that this is also the angle between the normal, CM, to the tangent plane, and the xz-plane, as indicated in the figure.

Then, since α, θ, ψ form the three sides of a right-angled solid (spherical) triangle, right-angled opposite ψ, along the trace, CP, we must have,

$$\cos\psi = \cos\alpha\cos\theta;$$

from which

$$\cos\alpha = \frac{\cos\psi}{\cos\theta} = \frac{n}{\cos\theta}$$

and, thus,

$$\sec\alpha = \frac{\cos\theta}{n}$$

But

$$\frac{\cos\theta}{n} = \sec\beta\sqrt{1 - (\sin\theta\sin\beta)^2},$$

as shown above.

Therefore,

$$\sec\alpha = \frac{\cos\theta}{n} = \sec\beta\sqrt{1-(\sin\theta\sin\beta)^2},$$

which was to be shown.

THE LIFTING MAGNET; A VALUABLE PIECE OF LABORATORY APPARATUS.

BY L. A. DOGGETT AND C. A. STYER.

The magnetic circuit is obviously one of the fundamental concepts of electrical engineering. Any laboratory experiment that can help to make clear to the student the various characteristics of the magnetic circuit is a valuable one. The experiments about to be described bring out the following points: (1) Magnetization curve and saturation, (2) hysteresis effects, (3) law for the pull exerted by an electromagnet, and (4) effects of inductance in an electromagnet. This last item is one which needs more attention than it usually gets. In the class room it is customary to make some effort to get the student acquainted with inductance, but seldom, if ever, in the laboratory. More as to this later.

The lifting magnet used in these experiments is shown in cross section in Fig. 1 and has the following name plate data:

Cutler Hammer Mfg. Co.
Type B Size 18
Serial No. 647144
Volts 220 Duty, Intermittent.

The armature used in these tests was a square piece of cast-iron having machined surfaces and drilled at its center with a three-inch hole, as shown in Fig. 1. This armature was improvised from the materials of the junk pile, and probably much better results would have been obtained with a steel armature thick enough to prevent saturation.

PULL TESTS.

Considering first the pull tests, the apparatus was set up as in Fig. 2. In this figure, M is the lifting magnet; A, the ammeter; *S,* the controller which is wired as shown in Fig. 3, and *R,* the rheostats for varying the current.

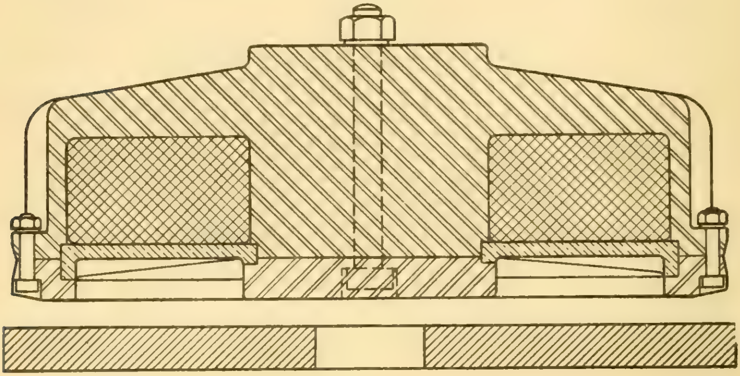


Fig. 1.

The cast-iron plate or armature is plainly visible in Fig. 2. To take observations of the pull, the procedure is as follows:

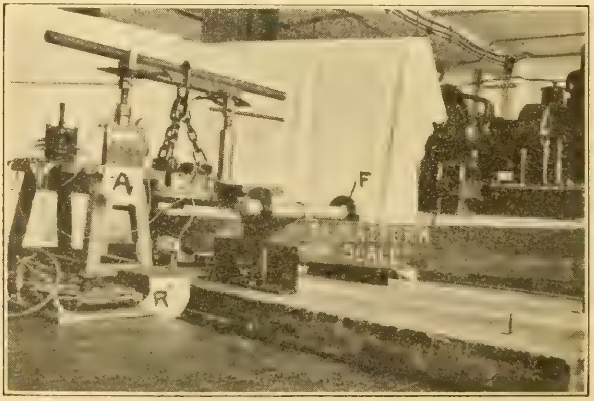


Fig. 2.

The magnet is lowered until the armature is firmly gripped, after which the magnet is raised by the jacks until the wooden beam is lifted in contact with the fulcrum, *F*. The downward force on the platform scales, not shown in Fig. 2, is then weighed. The jacks are then further raised, while the scale beam is being continually balanced and this balancing goes on until the magnet is pulled free from its armature. Table I gives a set of values for such a test both for increasing and decreasing values of current.

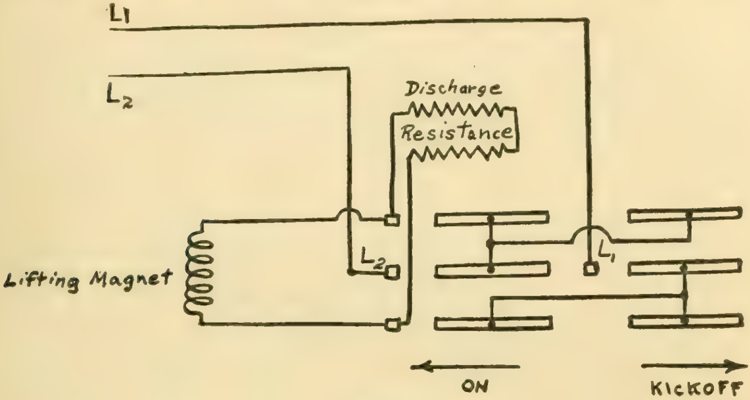


FIG. 3.

TABLE I.

I, Amperes.	Pull, Pounds.	Flux Lines, Inner Pole $\phi_i = 0.46 \times 10^5 \sqrt{\text{Pull}}$.	*I*, Amperes.	Pull, Pounds.	Flux Lines, Inner Pole $\phi_i = 0.46 \times 10^5 \sqrt{\text{Pull}}$.
0.40	906	1,385,000	2.10	3,626	2,770,000
0.50	1,366	1,701,000	2.28	3,916	2,880,000
0.60	1,596	1,840,000	2.54	4,236	2,992,000
0.71	1,976	2,044,000	2.32	3,786	2,830,000
0.81	2,166	2,140,000	2.10	3,686	2,793,000
0.90	2,366	2,232,000	1.88	3,646	2,780,000
1.00	2,356	2,230,000	1.69	3,506	2,721,000
1.12	2,716	2,400,000	1.48	3,276	2,635,000
1.29	2,886	2,470,000	1.30	2,986	2,512,000
1.52	3,146	2,580,000	1.11	2,626	2,360,000
1.70	3,346	2,660,000	0.90	2,356	2,230,000
1.90	3,420	2,690,000	0.70	1,876	1,991,000

Although a curve of pull *vs.* current might be plotted, it is more instructive to plot against current the magnitude of the flux of the inner pole, ϕ_i. The relation of flux to pull is

$$\phi_i = 0.46 \times 10^5 \times \sqrt{\text{Pull in Pounds}}.$$

The details of deriving this formula are given in the appendix. Suffice it to say at this point, that the relation between pull and inner pole flux is derived from the fundamental law that

$$\text{pull in dynes per cm}^2 = \frac{1}{8\pi} \times (B \text{ in gausses})^2,$$

and that in calculating B, *effective* air gap areas were used. Furthermore, due account was taken of the fact that only a certain fraction of the inner pole flux enters the outer pole, the rest getting back via leakage paths through the winding space. In Fig. 4 is plotted then a curve of inner pole flux, ϕ_i, *vs.* current. This curve shows very clearly not only saturation from 1.5 amperes on, but also evidences of hysteresis, the observations for increasing currents being plotted as crosses and for decreasing currents as circles.

Thus Fig. 4 illustrates: (1) The magnetization curve and saturation for a magnetic circuit and (2) gives a forceful exhibition of hysteresis effects. In terms of Table I hysteresis accounts for one to two hundred pounds excess in pull when the current is decreasing, over and above the pull for the same increasing current. On the law for magnetic pull depends the method of obtaining the curve of Fig. 4.

INDUCTANCE TESTS.

Inductance has always been a difficult thing to explain to the beginner. Usually his only laboratory acquaintance with inductance is gained by measuring a reactance with alternating current and then obtaining a quantity which he is told to call the inductance by dividing the reactance by 2π (frequency). It is very possible for him to make this calculation without even a speaking acquaintance with inductance. Hence, we strongly advocate having the student obtain a curve of the form

$$i = \frac{E}{R}(1 - \epsilon^{-Rt/L})$$

some time during the latter part of his direct current course, being of the opinion that such an experiment will give the stu-

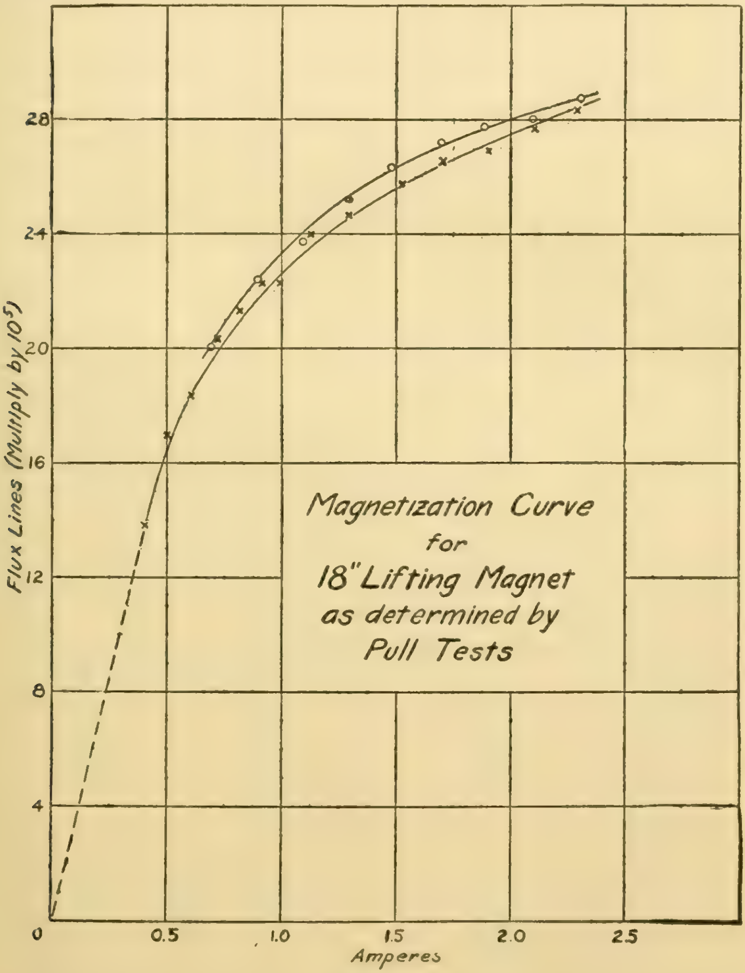


FIG. 4.

dent the sort of physical conception of inductance that will materially aid him both in his alternating current work and in his radiotelegraphy work.

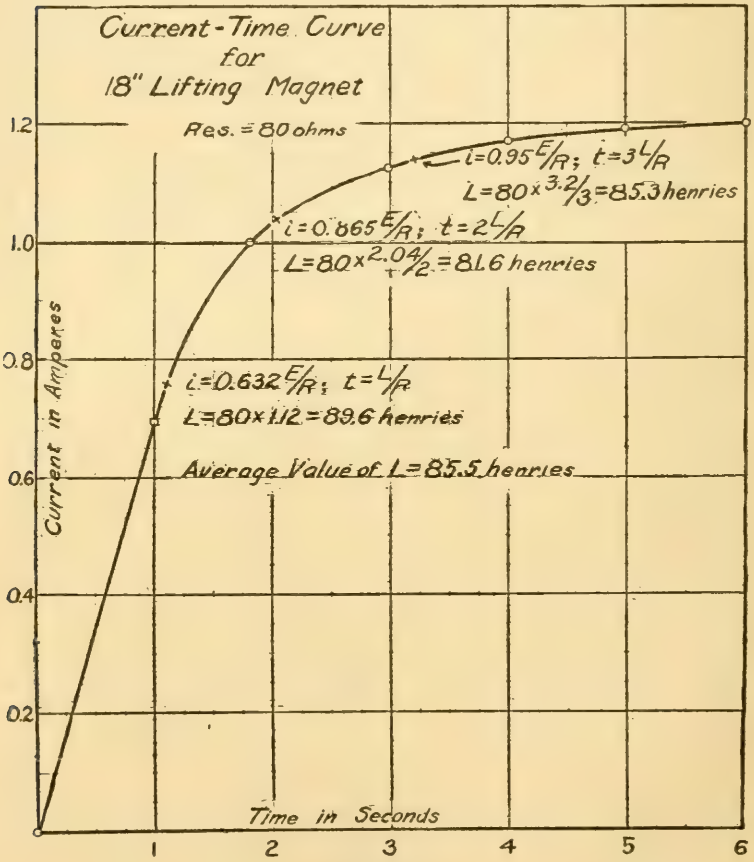


FIG. 5.

The lifting magnet provides a very satisfactory apparatus for this experiment, although of course it is not an apparatus of constant self inductance. However, the curve of Fig. 5, a curve of current *vs.* time brings out the possibilities of this sort of a test. Here the student can see inductance at work. He can get a rough approximation of the value of the inductance of the magnet, by using the fact that the current reaches 63.2 per cent. of its final value in one time constant, 86.5 per cent. in two time constants, and 95 per cent. in three time constants. The magnet used in these experiments had for various conditions of air gap and current values, inductances of from 50 to 100 henries. The resistance being about 80 ohms, the time constants dealt with varied from 5/8 to 1¼ seconds, values easily measured to a fair degree of accuracy with ordinary stop watches.

In the appendix there is submitted the outline of an experiment along this line, written for the use of elementary students in the United States Naval Academy.

Appendix.

1. Derivation of Pull Formula.

In Table II is given the value of the inner pole flux, ϕ_i, for increasing and decreasing values of current, the flux being determined by a two-turn exploring coil around the inner pole of the magnet. The ends of this coil were twisted up and led out through a hole in the outer shell of the magnet

TABLE II.

Current in Amperes.	Flux Lines, Inner Pole by Exploring Coil.	Current in Amperes.	Flux Lines, Inner Pole by Exploring Coil.
0.155	573,000	2.470	2,990,000
0.220	778,000	2.300	2,940,000
0.320	1,126,000	2.000	2,833,000
0.700	1,842,000	1.780	2,740,000
0.900	2,052,000	1.540	2,620,000
1.325	2,426,000	1.330	2,493,000
1.570	2,585,000	0.910	2,145,000
1.850	2,740,000	0.680	1,878,000
2.100	2,840,000	0.325	1,212,000
2.380	2,948,000	0.220	895,000
2.520	2,992,000	0.160	700,000
2.710	3,052,000	0.000	11,010

to a ballistic galvanometer. This ballistic galvanometer was calibrated by the usual long solenoid method and hence the data of Table II are not relative but absolute data of a fair degree of accuracy.

Assuming then these data to be accurate, it was obvious for two reasons that all the flux that left the inner pole did not enter the outer pole. The first reason for this conclusion is that the pull would have been much larger than the measured pull if all the inner pole flux entered the outer pole. The second reason is that since the value of inductance calculated on the basis of

$$L = \frac{\phi_i N}{I} \times 10^{-8}$$

for $I = 0.5$ ampere was 160 henries or much too large, therefore not all the inner pole flux entered the outer pole. That there should be a great deal of flux that did not go through the cast-iron armature is obvious when we consider the cross section of the armature and the resulting saturation if ϕ_i were all carried by the armature.

Coming now to the derivation of the formula connecting ϕ_i and pull, start with the fundamental law,

$$\text{Pull in dynes per cm.}^2 = \frac{B^2}{8\pi}.$$

From this may be derived the following:

Total pull of magnet in

$$\text{pounds} = \phi_i^2 \frac{138.5 \times 10^{-10}}{A_i} + \phi_0^2 \frac{138.5 \times 10^{-10}}{A_0},$$

where A_i and A_0 are respectively the effective areas of the inner and outer poles in square inches. Considering the three-inch hole in the armature and making some allowance for fringing $A_i = 34.6$ square inches. Taking account of the fact that the outer pole is not flat but bevelled, $A_0 = 39.7$ square inches. Taking into consideration the data of the pull curves and the data on the inductance, a conclusion was reached that on the average only about 45 per cent. of the inner pole flux entered the outer pole. Substituting this information, we have

$$\text{Total pull in pounds} = 4.71 \times 10^{-10} \phi_i^2,$$

or with an accuracy sufficient for the present purposes,

$$\phi_i = 0.46 \times 10^5 \times \sqrt{\text{Pull in Pounds.}}$$

2. Sample Inductance Experiment.

INDUCTANCE.

Object.—The object of this experiment is to study inductance.

Apparatus.—An 18-in. Cutler-Hammer lifting magnet. A low-scale ammeter. A stop watch. Rheostats for varying the current. A 220-volt direct-current source of power.

Procedure.—Arrange the armature with an air gap of about 0.25 inch. Set the rheostats so that the final value of current is 1.2 amperes. For 1, 2, 3, 4, 5 and 6 seconds read the value of the current. Read the current ten times for each point.

Measure the resistance of the magnet alone. Measure the resistance of the discharge resistance alone.

Results.—Using average values plot a curve of current *vs.* time. Assuming that the curve you have is a true logarithmic curve (*i. e.*, 63.2 per cent. of final value reached in one time constant, 86.5 per cent. in two time constants, and 95 per cent. in three time constants) calculate three values of the inductance.

Questions.—With the present discharge resistance and an impressed voltage of 220, what is the maximum possible value of voltage across the magnet when the switch is opened?

If the magnet has 5,000 turns, what flux must link these turns to give an inductance of ———————— henries at 1.2 amperes?

References.—Bullard's Naval Electricians' Text Book, Volume I, 1917 edition, pages 110 to 114.

ARMY EDUCATION IN WAR ISSUES.

BY LOUIS K. MANLEY,

Assistant Professor of Economics, University of Pittsburgh.

It requires more than training to make a soldier. The will to fight can make a man valuable in his military unit though his physical qualifications for the army are barely sufficient to pass army standards. A well-trained soldier who is only in part convinced that his cause is one worth fighting for is not worth enough to any army to repay the government that trains him. In Belgium those men whose lot it was to face the Hun on the outskirts of a familiar little village needed no other incentive to fight to the death than the realization of what would happen to their own home folk if the thin little line should break.

In 1914 the causes of the war and the knowledge of what a victory for the Central Powers would mean in Europe were part and parcel of the mental equipment of the soldiers of the Allied European Powers. The aloofness of the United States regarding questions of vital interest to Europeans prevented many individuals in this country from knowing the true situation in Europe. German propaganda in America from 1914 to the time of our entrance into the war was designed so to becloud the actual situation and so to conceal the real purposes of Germany that American sympathy should not have an opportunity to definitely crystallize and align itself with the Entente Allies. In part this propaganda was successful, but only in part.

This was the situation when, in April, 1917, for reasons quite sufficient and too well known to require recounting, the United States declared war upon Germany. Had our issues with Germany been solely those of a type with which the average American was familiar we could have taken for granted the existence of the point of view which is an essential asset for the successful prosecution of a war. But the complexities of the international situation, the wide circulation by paid agents of Germany of wilful misrepresentation of facts, the strong desire of America to remain at peace if peace were possible with honor, the hesitancy of America to realize that the reported German methods of carrying on war were true, the difficulties of weighing the tremendous mass of diplomatic material which so clearly placed the responsibility of this world war upon the German Empire, all of these combined to make a problem somewhat too difficult for the casual reader to face in such a way that his decision should emerge clear cut. Never before in history has a nation engaged in war for more just reasons or from higher ethical motives than in the case of the United States in its declaration of war upon Germany. Our soldiers and civilians must not merely feel this through chauvinism or blind patriotism but they must know it through actual contact with the bitter truths that show Germany and her allies as they are.

If the United States were raising armies by the volunteer plan, every man in the army would be there because of a personal conviction of duty; but in raising armies by the draft it is obvious that many men are in service who would not have enlisted. We owe it both to the efficient conduct of the war and to the men themselves to see to it that every man in the service of the United States is made familiar with the whole war situation. No sane man placed in touch with the facts could possibly reach any other conclusion than a conviction through which his whole mind and soul would be as thoroughly enlisted in service as his trained body.

Soon after the United States entered the war there were desultory efforts in our cantonments to render to the men a service concerning war information. Later, a Committee on War Education devised a plan of systematic work in ''War Aims'' as a part of the military training of the soldiers. In the various institutions to which men were sent for training along mechanical lines, each man was required to attend a one-hour meeting every week for a study of "war aims." Since ordinarily the men left the institution at the end of eight weeks the instruction had to be confined to eight meetings. Usually the following topics were discussed: The International Situation in 1914, The Causes of America's Entrance into the War, America's Accomplishments in the War, The Governments of the Central Powers (autocracy revealed), The Governments of the Allies (democratic principles presented), A Review of the Various Peace Proposals.

Of necessity these subjects required a rather formal presentation. This was only a part of the "war aims" work; a second part consisted of a survey each week of the leading events of the week as shown by the official statements of the governments and by the responsible American and European press; at each meeting during a period of about twenty minutes, the fullest opportunity was given for an interchange of questions and answers between the soldiers and the instructor. The nature of the questions asked revealed interesting and curious viewpoints, some of which innocently reflected the results of German propaganda. Another feature of the course with motor mechanics was the meeting of the instructor with the soldiers in the Y. M. C. A. recreation hut or in the barracks. Here, because of the very informality of the meeting, questions were often discussed which led to a better understanding of various phases of a situation than could possibly have been obtained in the class-room.

In teaching "war aims," the material which is given to the men and from which the instructor secures his information must always be of unquestionable authority and no statement must be made for which authority can not be cited. At no time must the instructor permit his patriotism to beguile him into statements which will not bear the light of investigation. When the week's news is being discussed the men should be warned that, while the events of the week as stated by our leading press associations are usually correct, the press statements may occasionally be unreliable.

The result of this work has been amazing. The men have been delighted to have their patriotic convictions sustained by fact. Besides profit the men seem to have found pleasure in the course. It is no unusual thing for the instructor to be greeted with applause and it is exceptional for the hour to close without it. Men who have been out on guard duty and who are not required to attend the "war aims" hour will often forego an hour's sleep to attend "war aims." Unquestionably the work in this field has helped to fuse the great mass of material in the minds of the men into the firm conviction of the justice of the American cause and the danger to all democratic institutions of the German type of government.

The results mentioned show why a course in "war aims" was placed upon the army schedule. "War aims" in the student army training corps represented a somewhat different problem. The S. A. T. C. is the training school from which officers for the United States Army are to be selected. In all of the hundreds of colleges taken over, in part, for S. A. T. C. work the "war aims" course is required of all students except a very few of upper collegiate rank and a few others who are carrying work in certain professional schools. Each student taking the course in "war aims" is required to spend nine hours a week in connection with the course,—three of these in the class room and six in a study room under military supervision.

In all of the colleges and universities carrying on S. A. T. C. work the "war aims" course is organized in accordance with directions from Washington signed by the educational director. As a consequence one might expect identical content in the course as offered by various institutions. Anyone who has had occasion at any time to follow a general order through a career of individual interpretation need not be told that the final reactions of the institutions toward a "war aims" course are capable of considerable variation. In no case however will the spirit of the execution of the order be out of harmony with the purpose of the educational director.

Where the college or university is sufficiently well staffed with men whose special fields of interest and training are such as to particularly equip them for intelligently discussing war problems, a coöperative course in "war aims" is offered. Each specialist takes a group of men and discusses with them the war situation from the point of view of his specialty. The men are then turned over to another specialist in another field and so the work is continued until the prescribed course has been covered. The following subjects were selected by the educational director as desirable for study, from the standpoint of "war aims," history, government, economics, philosophy, and modern literature.

These subjects are not taught with the usual collegiate content. The history is such as will make intelligible the sequence of events which reached their climax in the world war; the government is chiefly designed to contrast the autocratic governments of the Central Powers with the democratic governments of the Allied Powers; the economics is to show the tremendous influence of international economic relations in shaping national policies; the philosophy is to reveal the control of certain German philosophers over German national thought and to direct attention to the trend of philosophical thought among the Entente Allies; the modern literature is to find its opportunity in the presentation of national ideas and ideals as expressed in the literature of the various nations.

In smaller institutions, where the entire field of social science may be taught by one or two men, the "war aims" course will by necessity be shaped accordingly. In such institutions one instructor will doubtless remain with a group until the course is completed. The course as outlined is both broad and deep.

Having a student army training corps does not mean that we are simply placing a large group of men in colleges and universities for the old time collegiate instruction. The members of the S. A. T. C. are inducted into the United States Army. They are provided for exactly as all other privates in the United States Army are provided for. They receive thirty dollars a month pay. They are placed in the S. A. T. C. solely for the reason that they are to be trained, at the earliest possible moment, for service to the United States government. They do not receive a single hour of instruction that does not have definite military value. They receive no college credit for work taken, though doubtless there will be no objection to any institution granting credit if it wishes to do so. In brief, members of the S. A. T. C. are simply privates in the United States Army undergoing a very special form of training with the possibility of becoming officers if they show sufficient cause. If they fail to show such cause they will remain in the army as privates or non-commissioned officers but will be transferred out of the S. A. T. C.

The officers selected from this group will probably represent our country upon a foreign field. The "war aims" course will have given to them an elementary knowledge of the issues involved in the war. Their patriotism will be more intelligent and their services to the United States more valuable because of their course in "war aims." It is to be hoped that the hurried glimpse these men have had of some institution of collegiate rank will prove a lure that will draw them back after the war for continued study. We must not forget that democracy can never endure where education is not fostered.

AN ANALYSIS OF MECHANICAL ENGINEERING COURSES.

BY C. E. PEARCE,

Assistant Professor of Applied Mechanics and Machine Design,
Kansas State Agricultural College.

Choice of Colleges.

Agricultural (Land Grant) Colleges not connected with State Universities:

1. Kansas (3 terms).
2. Iowa.
3. Purdue.
4. Michigan.
5. Oregon.
6. Pennsylvania.
7. Texas.

Agricultural Colleges combined with State Universities:

8. Cornell.
9. Wisconsin.
10. Ohio.
11. Nebraska.
12. Kentucky.

State Universities not connected with Agricultural Colleges:

13. Kansas.
14. Michigan.
15. Iowa.
16. Colorado.

Privately Endowed Colleges:

17. Mass. Inst. of Tech.
18. Lehigh.
19. Carnegie Inst.
20. Case School.
21. Armour Inst.
22. Worcester Polytech.
23. Leland Stanford.
24. McGill (Canada).

Subject Headings.

Arts Group:

1. English.
2. Public Speaking.
3. Modern Languages.
4. History and Civics.
5. Economics.
6. Business Law.

ANALYSIS OF MECHANICAL ENGINEERING COURSES.

Science Group:

7. Chemistry.
8. Physics.
9. Lower Mathematics.
10. Calculus.
11. General Drawing.
12. Descriptive Geometry.

Technical Group:

13. Wood Work.
14. Foundry.
15. Forge.
16. Machine Shop.
17. Metallurgy.
18. Engineering Drawing and Design.
19. Factory Engineering and Design.
20. Engineering Mechanics.
21. Hydraulics.
22. Steam and Gas Engineering.
23. Heating, Ventilation, and Refrigeration.
24. Power Plant Engineering and Design.
25. Electrical Engineering.
26. Surveying.
27. Seminar.
28. Thesis.

Miscellaneous Subjects:

29. Arts Group.
30. Science Group.
31. Technical Group.

Elective Subjects:

32. Arts Group.
33. Science Group.
34. Technical Group.

Subdivisions, from No. 18 to No. 24, inclusive:

x. Time in Recitations and Lectures.
y. Time in Drawing Room Work.
z. Time in Testing Laboratories.

EDITORIALS.

The Report of the Joint Committee on Engineering Education.—The report of the Joint Committee on Engineering Education by Dr. C. R. Mann is now in the hands of all members of this Society. It represents the result of years of study not only by Dr. Mann himself but by individual members of the committee, many of whom devoted a large amount of time to this subject. It has been the subject of discussion at numerous meetings not only of this but other engineering societies. A special committee was appointed at the Northwestern meeting to consider this report in detail and report at the annual meeting next June. Due to the war and the establishment of the S. A. T. C. this epochmaking report has not as yet received the consideration which it should. However, some institutions are already considering the modification of their courses to meet the recommendations in this report. Perhaps, the most important of these is that which deals with the coöperative work, which provides actual practical engineering work for the student while he is taking his course, thus insuring his familiarity with engineering work before he completes his theoretical course. The report deals at length with the system originated and developed by Dean Schneider at the University of Cincinnati. It does not recommend the adoption of this exact form but some method which may be devised to insure the student securing the necessary training in engineering industries.

Membership.—The membership of this Society has remained practically stationary during the war. With the signing of the armistice and the returning of many instructors to the colleges, the membership should be increased so that the Society can do efficiently and well the work which it should do. Every member of the Society should consider himself a member of the Membership Committee to encourage especially the younger members of the teaching profession to not only become members of the Society but to write papers for ENGINEERING EDUCATION, be present at the annual meetings and take part in the discussion.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., DECEMBER, 1918 No. 4

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THE LIBERAL ELEMENT IN ENGINEERING EDUCATION.

BY GEORGE F. SWAIN,

Professor of Civil Engineering, Harvard University.

I have been asked to speak on this topic, which has been selected, I assume, by some committee. I will endeavor to present briefly my views upon the subject. Let me first state some principles which may make the consideration of the subject easier, and focus differences of opinion.

1. In the words of that fine old English schoolmaster, Richard Mulcaster, who wrote over 300 years ago, which cannot be improved even today, "The end of education and training is to help nature to her perfection in the complete development of all the various powers." Its aim is to give the student power to meet the problems which life will bring him.

2. Education is strictly utilitarian, using the word in its widest sense. The student should be taught first what is necessary, second what is useful, third what is ornamental. All of these are utilitarian, or useful in the largest sense.

3. The objects to be aimed at in education are mainly two, viz., discipline of mind, and interest; knowledge is secondary, but discipline should be acquired in subjects which will bring knowledge with it.

4. No effective results will follow unless the student is interested and sees the value, use, and application of what he studies.

5. A student cannot appreciate what he studies, or become really and profitably interested in it, in a concrete way, unless he can relate it to his experience.

6. Education cannot turn out a finished product, that is to say, a man fitted to take a responsible position at once. It can only fit him to begin at the bottom of the ladder, and give him the foundation upon which to build. Experience is necessary before he can advance, but if he has a well-trained mind and the proper attitude, he should gain and assimilate experience rapidly, and progress much faster than otherwise.

7. We live in a world of other men. In order to make our way, we need, besides a disciplined mind, many other qualities, such as knowledge of men, tact, personality, perseverance, energy, enthusiasm, power to concentrate, ability to work hard and effectively, and above all, character. Education should aim to cultivate such qualities as far as practicable.

8. In education, much more depends upon how a subject is taught and the personality of the teacher, than upon what is taught.

9. Education may on the one hand be liberal or professional, or it may be vocational. The latter aims to fit young men specifically for some definite occupation, such as a manual trade, or for stenography, bookkeeping, etc. Professional education has essentially the same object, except that a profession is broader in scope and requires a stronger and broader foundation of general principles. Vocational education may be concerned mainly with training the body, or even one muscle, rather than with training the mind. Vocational education will not be considered here, but it may be remarked that it possesses in a marked degree one of the most important elements, namely, interest. The pupil becomes at once interested in the work, it is related to his experience, he sees the use and meaning of it all the time. Its results are therefore apt to be very satisfactory, even more so than the results of more formal education, and its importance is steadily increasing with the recognition of the fact that one of our main problems is to put the boy in the right place and fit him for some specific job.

10. Engineering education is in a sense vocational, but since the field of engineering is very wide, and rests upon a substantial body of principles of science, it must be broad and deal rather with those general principles than with any specific job. Yet the line between the two is not sharp, and many graduates of vocational schools make the best of engineers ultimately.

The question as to the liberal element in engineering education, or a liberal education by itself, arises from a recognition of the fact, above referred to, that since we live among men, an educated man should have some knowledge outside of his own vocation, of language, literature, history, and economics, so that he may understand and appreciate what goes on about him, that he may know something of the thoughts and deeds of the great men of the past, and may be able to write and to express himself clearly and logically. Without these things, a man may have great skill and knowledge, but not attain his greatest usefulness or development.

The difficulty is that in the study of these subjects the student may not be able to relate them to his experience, that is, his work is not *motivated,* and so he achieves small results. The subject of this paper is mainly *motivation,* or doing work with a distinct motive, gained by being able to see what is being done, the need and use and application of it, which is only possible, if my view is correct, if it can be related to experience. It is a great fallacy to suppose that a boy will gain what is called culture by listening to courses of lectures, especially if he is not interested in them. Some of the most uncultured men are college graduates.

Few students take much interest in Greek and Latin. Those tongues are dead, and the student does not realize their significance in relation to our own tongue. Modern languages have more interest to him, because he can use them. History may interest him little because it does not deal with the present, and he cannot relate it to the present and coördinate it with his daily life. Economics he may think he can understand, because he hears it talked about so much, but since it deals with business questions in which he has had no experience, he really cannot grasp it concretely or safely. Science, mechanics and engineering he can understand, because he lives in a world of science and engineering, he can relate these to his experience; yet even in these subjects we take pains to relate them to his experience still more closely by providing laboratories. Even this is not always deemed a sufficiently close relation, and we employ the coöperative system, as at Cincinnati, where the pupil alternately studies and works in a shop and so is, as Mulcaster advises, "a-doing while he is a-learning." Mathematics, in arithmetic, he can relate to his experience, for he has to buy and sell and make change every day; but in its higher branches it is abstract to him, he does not interpret or grasp it, and this is perhaps the reason why so many boys hate it, unless it is taught and used distinctly as a tool in connection with science and engineering, and preferably taught by men who themselves use it in their daily work.

It is of course true that there is such a thing as a stimulus lasting a lifetime derived from a single lecture, a single point of view, a single idea. But such a stimulus may as well be gained from a sermon, an academy lecture or a conversation with a friend. We should not judge a college course on such a basis, except that we should try to have stimulating teachers, who would look beyond the narrow confines of their subjects, deal with the individual student as much as possible, meet students outside the class-room, and try to influence not only their knowledge but their character.

The key to effective instruction, it seems to me, is motivation. Relate the subject to the student's experience. If it cannot be so related effectively, better not teach it. We make a common mistake when we assume that when a subject is put into the curriculum it is put into the student. We cram the curriculum full of every subject of human interest, regardless of whether the student can relate it to his experience. If he does not so relate it he will generally take no interest in it and get nothing out of it. If he does take an interest in it, it will often be by relating it, not to his experience, but to his imagination, and in this case he will get less than nothing out of it; it will do him harm. He will become a theorist who does not care for facts, but only for his imagination and his preconceived ideas.

Some subjects are difficult to motivate and should not be taught in school. History is often not related, if taught as a barren chronology of facts, but if made live by showing the causes and effects of great events, the tendencies of the times, and illustrated by the characters of great men, it may be one of the most useful of studies. But history cannot be related experimentally in the laboratory. Sometimes, in the laudable effort to motivate, ludicrous and time-consuming methods are resorted to, as when a class in American History was made to "live" their history by building Indian wigwams. In such a subject everything depends upon the teacher and *how* the subject is taught.

Economics is difficult to motivate, since it deals with complicated matters of business, not within the range of experience of the student. I have long believed that the excessive teaching of this subject now quite common was not only profitless, but injurious, notwithstanding the intrinsic importance and interest of the subject. The student will frequently find in this subject his own teacher, an eminent man, holding opinions diametrically opposed to those held by an equally eminent teacher at a neighboring college, while neither can be demonstrated to be in error. What a field is here for the cultivation of a dependence upon preconceived ideas, even if contrary to facts! The inherent importance of the subject may enlist the interest of the student, but he cannot relate it to his experience, and so relates it to his imagination or his sympathies. His sentiment is stronger than his reason, and he becomes a faddist, indulging his preconceived ideas at the expense of society. Perhaps no subject depends so much upon having a safe, logical, unemotional teacher, himself experienced in business affairs or capable of seeing them without distortion. One brief course in the subject should suffice to give the student an idea of its scope, methods, and general principles, and an outlook over the problems with which it deals, sufficient to serve as a basis for later study, as he gains experience in the business world.

I was talking last summer with a young banker, who had taken in college, in anticipation of his career, a course in banking and finance. He said that he got absolutely nothing out of it, and, furthermore, that he knew his classmates well, and that none of them had got anything out of it. The teacher had had no banking experience, was a theorist, and shot entirely over the heads of the students, who did not have the faintest idea what he was talking about.

If the subjects in economics and sociology could be taught as my friend Professor ——— teaches them, all might be well. The student would gain safe, sensible views of very important problems, and might learn to see the fallacies in many current and plausible economic theories. Yet even so, he would be exposed to the danger of discovering that his teacher held views perhaps not commonly accepted, and so he would still run the risk of allowing his preconceived ideas, or his sentiments, to govern his views, rather than reason and experience. And then there are Scott Nearings in our colleges, whose influence might be not only little, but positively vicious. A bad teacher of science, or of mathematics, or of engineering may do little good, but he can hardly do positive harm. At the most the student learns nothing from him. But a bad or unbalanced teacher of economics may do positive harm, in inculcating unsound and vicious economic theories into the minds of immature students who have not the experience nor the trained logical minds to discover the errors. The best training for the study of economics, I think, is a training in science, so that demonstration may be distinguished from hypothesis, and truth recognized when found. A subject on which opinions differ widely, while few can be demonstrated to be correct, does not appear to be a good one for an immature and untrained mind, though it may be a very useful subject of study for a mind already trained in logical methods, and with experience as a guide. Personally, I believe that the excessive study of economics in our colleges, and the turning out of large numbers of young men who have "specialized" in this subject, and who go out into the world thinking they know all about these great questions, though totally without practical experience, and without training in scientific methods of investigation as well, is one of the most serious menaces to our country. You cannot experiment by the scientific method in economics, because you cannot vary one element only. There are always many elements, the relative influence of which cannot be measured. After a young man has studied science thoroughly, has learned the scientific method, and has acquired the scientific attitude of mind, it is time for him to study, in detail, the great questions of economics, and not till then.

Some branches of economics may be motivated. One of these is accounting. Every boy keeps, or should keep, a cash account, and the study of double entry book-keeping is not only a means of excellent mental training, and of the principles of accounting, but is eminently practical. The same is true of the elementary parts of other branches. The engineering student should be taught what a bank is and does, how he can use it, the methods of promoting and organizing a business enterprise, the different kinds of securities, and so on. Some topics connected with business management, the methods of securing efficiency, the importance of cost data, may also be taught to advantage. The elements of business law may also be appropriately included.

The classics have gradually been falling into disrepute as liberal studies. Nevertheless, I have always been disposed to value them highly; not so much for the language itself, although that is important as a basis for our own, but more for the acquaintance which the study gives with the literature of a great epoch, and the characters and thoughts of great men of the past. I agree entirely with the views of Senator Lodge in his remarkable address last year at the Princeton Conference for the revival of classical studies. Yet I think perhaps Senator Lodge makes the mistake of assuming that because of the importance of these things they will be gained by a college course. Doubt on this score may be suggested by his own words, in his "Early Memories," where he writes of his college course as follows: "But in all my four years I never really studied anything, never had my mind roused to any exertion or to anything resembling active thought until in my senior year I stumbled into the course in mediæval history given by Henry Adams." He also says that although "college is supposed to be a place primarily if not wholly for education and the improvement of one's mind" he got very little of either, and that his "greatest and most profitable enjoyments were derived from the many friendships (he) then made or continued." We also remember that Emerson said that the boy goes to college to be taught by the professors, but it is his classmates who educate him.

One of the best of liberal studies is English, particularly if including a course in Logic. Surely few things are more important to the engineer than the ability to write a good report, and to express himself clearly, forcibly, concisely, and logically. But the course in English should not be the traditional course. It is of little importance to the engineering student whether Keats was a greater poet than Shelly; but if the student is led up to the study of good writers through his own experience in trying to express himself, or by seeing the relation of the subject he reads about to the necessities of his own profession, he will gain an interest heretofore often lacking. Some courses in English are now being conducted in a way to secure this result.

But in recognizing the importance of liberal studies for engineering students, or for any students it may be proper to say a word as to the importance of science, for students of liberal arts and other than scientific professions. Of all studies, the sciences and their applications are probably the best and most useful, as a means of discipline, for their motivation, and for the knowledge and even character that they impart. This has been shown at length by Herbert Spencer in his book on education. The sciences offer all the elements of logical analysis, hypothesis, experiment, verification. They are not rigid, like mathematics, but afford room for doubt, hypothesis and argument. Neither are they vague and incapable of demonstration—mere matters of opinion—like many branches of economics. Moreover, every youth should have disciplined knowledge of the world in which we live and the physical phenomena which he experiences every day. Yet in some of our colleges it is possible for a boy to graduate without taking in college a single course in natural science or in mathematics. If I recognize and urge the importance of liberal studies, and even of the classics, for all broadly cultivated men, I must even more urge the importance of science for every man. I believe that in our colleges we are committing the great mistake of neglecting science in favor of economics, sociology, and literature, which are far inferior in disciplinary value and in power of motivation.

The effect of the war on education will no doubt be great. It has already taught us that many things previously thought impossible can be accomplished. It seems to me that its effect on education will be to cause us to make our work more efficient, by making it more practical, more directly useful, and to motivate it as far as possible.

In engineering education by far the greater part of the time must be devoted, as formerly, to professional work. Liberal studies must remain secondary, and occupy but a very small part of the time, but they are especially in need of motivation. I think they will consist mainly of thorough work in English; some modern languages, which will now be of greater importance than heretofore, unless these can be taught in the preparatory schools; some history, treated especially in the light of the great events we have been witnessing; and a brief general course in economics, supplemented by accounting and some treatment of banks, securities, organization, business law and business management. These subjects must all be treated in such a way that the student will relate them to his experience, and will look upon them as live realities, important to him in his profession, and forming part of the intellectual equipment and training of any broadly trained man. The courses in economic subjects should be put in the last year of the course, so that the students will be as mature as possible, and will have previously had a training in science. But along with liberal courses should go a greater liberalism in technical courses as well. There are few exercises in technical subjects, unless they are purely lectures, that will not give the qualified instructor an opportunity to illustrate some moral or economic or logical point outside the narrow scope of the course. If the instructor has a knowledge of history, biography, economics, and business, he can vivify even dull technical details by their aid.

The motto for the future, it seems to me, is—Make the instruction practical, useful, and well within the comprehension of the students and the field of their experience—motivate it.

THE EFFECT OF THE WAR ON ENGINEERING EDUCATION.

BY C. R. MANN,

Head, Educational Department.

The Society for the Promotion of Engineering Education has always been a leader in college education. It was the first association formed among college teachers for the purpose of studying their teaching problems. Its meetings are always the most interesting of educational gatherings and one of its committees discovered the clue that gave the schools their opportunity to help win the war. Now that the fighting has ceased, it is fitting that this Society should take the lead in conserving the benefits that have accrued to education because of our participation in the struggle.

It must be obvious to everyone that as yet the war has had but little effect on education. For the first year, the schools preserved their academic routine undisturbed. Their subsequent experience with war training has been so brief that no settled habits have been acquired and permanent results will be secured only if the schools resist their natural tendency to relapse to their placid peace time procedures. In the past America has made many good resolutions in time of stress only to forget them when the national crisis was past. Hence before attempting to interpret the present war experiment with education or to appraise the profound changes wrought by the war in our national philosophy of life, it is well to remind ourselves of previous reactions on other similar occasions lest the benefits of the present soul-stirring adventure escape us.

In the pioneer days of the Pilgrim Fathers, the first school law of the Massachusetts Bay Colony (1642) authorized the expenditure of public funds for vocational education because it was of benefit to the commonwealth to train children in the manual arts. Again, in the midst of the toil and turmoil of the Civil War public funds were voted for the support of training in agriculture and the mechanic arts; and when in this present crisis the dependence of the nation's strength upon its mastery of materials became evident, the treasury was opened to develop manual skill and tool power, without which the nation could not wage war. The emphasis on ostentatious and cultural studies that distract men's minds from the rugged realities of existence was for the time being transferred to the mastery of the forces of nature through machines by which men magnify their strength.

The pioneer experiences of 1642 and the civil struggle of 1862 recognized the need for productive skill by passing laws, but they did not succeed in developing a technique of administering practical education. Such a technique has been striving for expression since the founding of the engineering schools. This war has crystallized the results on a national scale. On April 10, 1918, 10,000 young men were called to national service by the War Department and placed in schools for two months of intensive military and technical training. Most of the schools were reluctant to undertake this work because their traditions led them to believe that little could be accomplished in so short a time and because the type of work required was unconventional and not generally considered to be of university grade. The army's need, however, was great and the institutions from a sense of patriotic duty undertook the work with fine spirit and with a will. We are all familiar with the results. By June 15, 50,000 men were in training at 155 schools. This number was continued through the summer, graduating each month 25,000 men prepared for service as technicians in the army. Before the signing of the armistice, 130,000 men had been so trained and contracts had been let for training 220,000 more.

The method of training employed was one that has been successfully used in army and navy training stations for many years. It is based upon the conception that all men in the army are primarily soldiers, each with a specialized technical skill that may be relied on when emergency requires. Therefore, each man must be resourceful and eager to do his best under any conditions, besides having a certain degree of manual skill. To meet this requirement, a course was designed consisting of a combination of military drill, practical shop work and humanistic study. The military régime developed the men as soldiers, the shop work added practical skill, and the humanistic study gave them an understanding of why they were fighting.

Before beginning the instruction, a careful survey was made of the needs of the army in order to determine as accurately and definitely as possible the specifications for every job which soldiers were to be trained. The shop work was then planned to teach each man to do the particular job for which he was best adapted and for which he was to be held responsible in some army organization. The instruction consisted in a series of projects carefully graded in difficulty and requiring the exercise of ingenuity and resourcefulness for their accomplishment. In other words, the soldiers were taught to do by doing under conditions that resembled as closely as was practicable real army conditions. The ordinary manual training system consisting of a set of predetermined exercises in the fundamental operations of machine shop practice was abandoned as unsuited to this particular task.

In like manner, the humanistic work was designed to answer the many questions asked by the soldiers concerning the issues of the war. The class work was a continuous discussion of these questions accompanied by outside reading by means of which the student could secure the facts and information that would enable him to answer his own questions intelligently. Some forty thousand of the soldiers' questions were collected, sorted and classified and a brief manual issued which contains the most frequently asked questions together with references to documents in which the answers may be found. This course was not in any sense a propaganda for any point of view but an effort to help men to discover the facts that would enable them to draw their own conclusions on the larger questions involved. The course was also unconventional in that it was not given by any one academic department but by the coöperation of the best men in all the different departments involved.

From the large mass of testimony that has accumulated in the past few months from both the army and the schools, it appears that this organization of technician training has proved highly successful. Military officers assure us that after two months of this combined training, the men have made as good progress in their military work as is ordinarily the case after two months devoted to military training alone in the cantonments. In the shop work, the men have acquired skill and understanding of their problems at an amazing rate. Bank clerks and barbers, salesmen and many others who had never worked with tools before have been converted in this shore time into satisfactory technicians for army use. The war spirit, the reality of the work, the progression from application to theory and the snap of military discipline have all conspired to achieve results that before the war were pronounced by the schools to be impossible.

The experiment of training young men for officer training camps in the Students Army Training Corps in colleges, which was begun on October first, has not yet had time to demonstrate the effectiveness of the methods employed. Interrupted as it was for three weeks at the beginning by the influenza, it had only three weeks of actual trial. While in many cases considerable difficulty was experienced in adjusting the military with the academic routine, eighty-five per cent. of the schools have just expressed their desire to retain the system to the end of this academic year. Unfortunately, this cannot be done because the removal of the military necessity that makes it impossible to utilize the appropriations to carry the experiment further. All that can be said is that in many places the indications are that good results were being obtained, while in others the reverse was true. No final conclusions are possible.

The sudden conversion of the engineering colleges into military schools and their equally sudden reconversion to civilian schools, have left them in a wholly disorganized state. It is therefore a most propitious time to reorganize them and to be guided in this reorganization by the lessons learned from the war experience. Besides the specific lessons as to methods of instruction and organization, demonstrated by the experience with vocational training, changes in the national philosophy of life are developing certain large new conceptions that have been gradually taking form and are now fairly well recognized as guiding principles for future development. Since this is an engineers' war, the engineering schools are particularly responsible for altering school practice to accord with these principles. It may safely be said that the future progress of this country depends in large measure upon how successful these schools are in this new enterprise.

In order to discover the guiding principles, our war experience may conveniently be analyzed under two heads, namely, (1) production of soldiers; and (2) production of supplies. In meeting the first of these requirements we have had little difficulty and delay. The Selective Service Law and the effectiveness of the military training methods have made it possible to transform civilians into soldiers in a remarkably short time. War is the most impersonal of all great issues and men are eager to subordinate their petty private ambitions to the one paramount purpose of victory. Military training and organization are the most effective means of accomplishing this end and friends and foe alike are lost in admiration at the speed and perfection with which this transformation was accomplished.

But while military training methods have proved efficient in the high speed production of soldiers, the fact remains that ships, airplanes and clothing have not materialized as rapidly as the soldiers required them. No official reports are yet available excepting in the case of aircraft production and this report indicates that the delay was due to the difficulties inherent in organizing a number of individual industries into a military unit consecrated to the single purpose of production. Such information as is available, indicates that the same is true with regard to ships, clothing and other supplies. In spite of the patriotic response of manufacturers and transportation managers as individuals, it was a relatively long and tedious process to subordinate to the public interest the private interests of numerous industrial companies and to coordinate them into a single production plant organized for the sole purpose of maximum production at minimum cost. In the case of the railroads the Federal Government had to take legal control before the result could be secured.

From these experiences it appears that the regimentation of individual men in military units, when required as a measure of preparedness for a future emergency, can be accomplished in a relatively short time. The personal willingness of individuals to serve their country, the local public sentiment against slackers, the respect for the uniform and the glamour of war, all stir the emotions and inspire men to make a concerted drive for national integrity. But corporations are less susceptible than individuals to personal emotions and enthusiasms and are therefore slower to subordinate their "lives, their fortunes and their sacred honor" to national welfare. Therefore any system of universal training which only drills individual men as soldiers, but which does not include as its major feature the reorganization of industry so that it will be capable of mastering production on a national scale, will be a partial and wholly inadequate solution of the problem.

The reorganization of industrial production is a task requiring a type of engineering ability that is at present very rare. It is the function of the technical schools of the future to develop men who can and will accomplish this intricate task. As at present organized the curricula are not designed to secure this result, because their avowed aim is to impart knowledge of the laws of physical science and of the properties of materials. But if we are to accomplish this task, we must add to this knowledge an understanding of the methods by which human wills are coördinated for team play not only in individual organizations but also in national enterprises.

The engineering schools have already recognized the necessity for instruction in human relations, as is evidenced by their recent introduction of courses in economics, sociology, industrial management and engineering administration. The mere superposition of these courses on existing curricula is, however, but a temporary palliative, because the reorganization of industry on the basis of national production involves a fundamentally new point of view, the implications of which reach to the foundations of our whole industrial system.

The larger outlines of the coming industrial system are now emerging from the toil and turmoil of the war. For when the war began everyone was certain that it could not last long because the bankers would stop it. Now everyone recognizes that the fighting continued so long as adequate supplies of men and material were maintained. This means that national strength in war depends upon production of men and supplies rather than on the financial system. Therefore, engineering, not banking, is the foundation of democracy's power.

But the war has not only made clear the general outlines of the new industrial system, it has also indicated the methods by which engineering schools can train engineers competent to meet successfully the heavy responsibilities that are from henceforth theirs. For although no conclusions are yet possible concerning the details of organization and administration of any plan that will meet the new conditions, the war experience seems to indicate that the following are the steps most likely to lead by experiment to conclusions of sound merit.

1. The War Department's experience with training soldiers shows that the first essential of effective teaching is a clear definition of the result desired. Theoretically, the schools have built their curricula to supply the elements required by the various types of engineers. As a matter of fact, however, much of the information and many of the methods now used in engineering schools are neither essential nor useful to engineers. If the courses are to be modified to place emphasis on production rather than on knowledge of the laws of physical science, new specifications of the essential factors will have to be written. This may be done by each school from a study of the actual operations of engineers in productive enterprises in their vicinity, or by joint action of national engineering societies such as this. No really intelligent changes can be made until there is a clear answer to the question: what are the specific requirements for each different type of engineer?

The war experience indicates that the definitions previously used for this purpose are too vague and uncertain to be expressed in intensive and effective work. It is also manifest that these definitions cannot be made by conferences of committees or by academic discussions at meetings like this, but only by actual and persistent study of the facts in the field.

2. A second inference from the war experience is that the content of the courses and the methods of instruction must be organized in such a way that every fact presented and every problem solved is relevant or contributes in an obvious way to the acquisition of some information or the development of some power required or mentioned in the specification. The conclusion of psychologists agrees with the experience of the war instruction that knowledge is always specific and is developed best by mastery of specific tasks.

3. In the third place, real military training and discipline have been demonstrated to be an essential element in the training of every engineer. Much confusion exists on this point because military training is often thought of as close

order drill and manual of arms, guard duty and other "stunts" of this sort. These are but the superficial forms of military discipline. The purposes of the entire military machine are to keep men physically fit and to train them so that each willingly subordinates his own individual desires and efforts to a common purpose to be achieved by the entire group. So far no better method than military training has been discovered to produce this result. But the result is as important in civilian enterprises as it is in war. Therefore careful consideration must be given to the question of how much military training is desirable or what better substitute, if any, can be found to accomplish the all important results of sound physique and discipline in subordinating petty personal desires to the welfare of all.

4. The army has long recognized that soldiers are better fighters if they have an intelligent conception of the issues of the battle. Many experiments have been made by the War Department to find ways and means of developing morale, but so far none has been more successful nor seemed more promising than the war issues course which has already been described.

For years engineers have been struggling to gain recognition as members of a learned profession. To this end, much has been written concerning the necessity for more intimate contact with the humanities in engineering schools. The question is here raised whether the introduction into engineering curricula of a course designed along the lines of the war issues course, but dealing with the issues of peace, might not be the best method of solving this intricate problem for engineers. The humanistic needs of the engineer are not satisfied by the current practice of requiring several years of linguistic training and brief courses in modern history or economics. Is it not possible that a course in which the wealth of material in history, in literature, in art and in philosophy was focused about the modern burning issues of peace might prove to be a most effective way of broadening the outlook of young men who are specializing in the highly technical branches of applied science? In order to facilitate experiment along these lines the War Department has arranged to supply the schools with materials dealing with the peace conference, the formation of a League of Nations and the reconstruction of our industrial system.

5. The final large contribution of the war experience to educational practice has been made by the army in the field of rating, testing and classifying men by objective methods. The army test for general intelligence has been found a most valuable method of selecting and classifying men for all sorts of army work. In one hour's time this test yields results which correlate so highly with the results of many months of personal experience with the men that all recruits are now required to take it when they enter the service.

In conformity with this general practice the War Department was about to require that all students in the Students Army Training Corps be given this test and that it be used as one of the factors in selecting men for admission to the corps and hence to college. The sudden and unavoidable demobilization of the corps has necessarily interrupted this experiment but it is believed that the schools will find it a most useful one to carry further. The Committee on Education and Special Training is prepared to supply the necessary blanks and instructions for schools that wish to make experiments with this test.

Examinations are generally used in schools for the purpose of debarring non-conformists from academic recognition. The use of tests as an incentive to good work and as a means of releasing creative energy has been but little recognized. The reason is perhaps that ordinary examinations do not really measure ability but rather the degree to which the student has conformed to the personal bias of individual professors. Certain it is that students understand full well how to "get by" examinations as now given. On the other hand, the test of the football field commands their profound respect because it is an objective "show-down" in competition with men who are recognized leaders. The new army tests are also objective. They open to the schools great possibilities of using their testing machinery as an incentive to spirited work rather than as a sieve for misfits.

6. Perhaps the most striking fact of the War Department's experience with education is that the federal government was willing to spend two hundred million dollars in one year on education. No such single appropriation for education was ever made in this country before. The reason is very simple. The national need was great and the schools had proved by their training of soldier mechanics that they could be relied upon to meet the national need. The primary purpose of the training was that each individual might be better equipped, not to realize his own personal ambitions but to serve the nation more effectively. The experience points to the conclusion that the public is ready to spend unlimited funds on education provided it is obvious to the taxpayers that thereby community, state and nation are being effectively served.

THE REQUIREMENTS OF A COURSE OF TRAINING IN NAVAL ARCHITECTURE.

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The present revival of shipbuilding in this country is bound to call for the establishment of new courses in naval architecture and the remodelling of the existing ones. For this reason I am prompted to place my studies and observations as a student, teacher, and naval architect before the engineering profession. The following views and recommendations are partly my own, and partly the collected opinion of a large number of men active in the profession, with whom I have been thrown in contact. The attitude of the student, and the early careers of the graduates indicate that the present system of training in naval architecture is in many respects deficient. In the following article I shall point out these deficiencies and outline a course in which they are eliminated.

The first requirement of a course in naval architecture, as well as in any engineering subject, is that only those who have the necessary qualifications should be encouraged to pursue it. By this, I do not mean that one should pass his entrance examinations successfully, although this of course is essential; but that the student have the necessary acquirements and proper temperament for the calling. He should show by his boyhood activities and interests that he has a natural bent for the profession; he should have a clear-cut conception of the nature of the duties that one in this line will be called upon to perform; and he should be fitted by ability and mental caliber for the work required in the engineering profession. In short, he should feel that he is claimed by the profession of naval architecture and not choose it blindly or in a haphazard manner.

Many times these qualifications are almost impossible to determine or analyze and, at the least, require much study and guidance. At present practically no attempt is made to guide the student in his early years. The universities and our Society especially could perform a great service by reaching out into the high schools and help guide the student in the selection of his life work.

While on the faculty of the University of Maine, I had personal talks with most of the upper classmen in my classes and many other students in the engineering courses of the university. The number of men who had chosen a particular branch of engineering without any worthy reason was almost beyond belief. Some had the proper qualifications to make good engineers if directed into the right field; others had none whatever. Any one who has been in a position to observe students floundering in the first years of their training must realize the need of serious attention to this requirement.

Later I shall discuss a system in which the student spends a year at practical work before entering college. By following this scheme the student acquires a wonderful insight into the requirements and duties of the profession he proposes to follow, as well as a knowledge of his own temperament and bent. It is one of the best methods possible of solving this difficult yet basic problem.

The second requirement is that the course of training be so laid out that a man will obtain a well rounded education and broad outlook, to fit him for the duties of a naval architect, shipbuilder, or ship operator. This should include the fundamentals of science and engineering; the technical design and construction of ships and marine engines; the management of the shipbuilding industry; and the operation and maintenance of ships. In addition to these purely professional subjects the course should include a fair amount of general education.

These subjects should be considered not only from the technical standpoint, but also from the practical and economical standpoint and the point of view of the business man. Such topics as initial cost, overhead expenses, cost of operation of ships, size of ship and earning capacity, types of machinery to install in a given vessel for a given trade, time required in port for unloading, etc., are all problems that the naval architect should be able to handle. The naval architect of the future will find these questions of equal, if not more importance than the more strictly technical problems of his profession.

In order that the student may master the essentials in the whole field of naval architecture, requires that he be in close touch with the practice and business management of shipbuilding and ship-operation from the very beginning of his studies; as well as pursue the customary course of study in college. It must be borne in mind that the student is preparing himself to earn a living in a world of business and the sooner he learns its methods and demands, the sooner he will meet with success in his profession.

To attain this end, practical work in the industry, by cooperation between the school and the shipbuilding plants and steamship lines, should be included in the course of training. The two existing courses in this country at the Massachusetts Institute of Technology and the University of Michigan do not take this point of view and I believe in this respect that they are weak.

One of the requirements for graduation should be that the student put in a certain amount of time in various capacities in the shipyards, engine works and at sea. A number of ways are open to accomplish this. One scheme which is followed pretty universally in England is to require several years of practical work before entering the technical school. Many of the leading men in naval architecture in that country started their training as apprentices in the dockyards. After several years of practical work and instruction in the yard school, they enter the technical school. The corps of naval constructors for the British Navy is educated in this manner. The achievements of such men as Sir William White and Sir Philip Watts certainly indicates that this method has considerable merit. As far as I know, this method is not used at all in engineering education in America.

The well-known Cincinnati plan, of two weeks in the industry followed by two weeks in school is another solution. The English ''sandwich system'' of a year in school alternated by a year in practical work is of the same character. Both have been criticized because the class room work is broken up and serious interruptions are introduced into the curriculum.

A third scheme is that of requiring practical work during the summer vacations. This system is already in use in some of the schools in this country.

From my own studies, I believe that a combination of the first and last schemes, requiring one year of practical work before entering college followed by three summers of work in the yard and at sea would accomplish the best results. This would give the student an insight into the profession and a tangible interest in the school work at the very start. It would either spur him on to better work in college or show him, before it is too late, that his real interests do not lie in the field of naval architecture.

It is very essential that all this practical work be directed by the college faculty and thorough coöperation, as in the Cincinnati plan, exist between the school and the shipbuilding and shipping industries. Otherwise the time of the student will be more or less wasted and the desired results will not be accomplished.

With the proper directing and planning of the high school work the course could be shortened so that the year of practical work need not necessarily lengthen the educational period. This, however, is not always possible or advisable and in such a case an extra year would be required. But the student who puts in an additional year in this manner should be further advanced at graduation than the student who has not; and in the end the period training will probably be shortened.

It is extremely important that the boy be guided in this year between high school and college; otherwise, as already mentioned, the time will be practically wasted. Care should be taken to see that his habits of study are not broken up, by prescribing a course of study and reading. I realize that the accomplishment of this plan requires earnest consideration and is not as simple as the mere statement might indicate.

The requirement in practical work should include experience in shipyards and shops where methods of construction and handling material can be observed; and experience in the drawing and designing offices where plans and technical calculations are made and material ordered. Then, some time should be spent in the shipyard offices where there is an atmosphere of business. Finally, a short time should be spent on shipboard where the handling of ships and their machinery can be studied. This part of the training will also give the student an opportunity to observe the action of a ship at sea which will cause him to take a more appreciative attitude towards the class-room work in stability and the strength of ships. If possible, a few weeks experience in a steamship office should be included in the training; so that the methods and practices of a steamship line can be observed.

If the above plan of practical training is followed, practically all the shop work can be dropped from the school curriculum. This will allow the time saved to be used for courses in literature, history, economics which at present are not given enough attention.

The practical work in the course as outlined would require about a year and a half of training outside of the class-room. I do not mean to assume that in this short time the student would become conversant in all the fields mentioned or become skilled in any trade or branch of the profession. In fact, I fear that he will have a rather superficial knowledge of the whole field, perhaps obscure in some particular branch. Nevertheless, he will have observed much that will incite his study and interest; he will have acquired unconsciously a knowledge of proportions and dimensions of machinery and structures that will be invaluable in his college work. He will have mixed with men of all classes and learned their point of view which is of prime importance for one who may in the future be placed in charge of men. Most important of all he will have seen the industrial world in operation and be infused with its methods and spirit.

Having considered the practical side of the training, let us now turn our attention to the school curriculum. The professional studies should begin at the start of the freshman year and not left until the third and fourth year as is the rule at present. I do not mean by this that an advanced study of naval architecture should start the first year, but that short introductory courses should start. The professional work should begin in an elementary way and gradually become more technical as the student masters the necessary foundation work in mathematics and physics. If it is unadvisable to start the work in naval architecture, due to the fact that the students have not decided on their course definitely, introductory work in general engineering could be given, paralleled by simple work in the laboratory.

There are three important reasons for starting the professional work early in the course and are of paramount importance when the practical work is to follow the scheme I have just outlined. First, it is necessary that the professional work parallel the outside training so that one will be an explanation and complement of the other; second, the students enthusiasm and interest in his life's work must be aroused early and kept constantly at the highest pitch so that he will get the most out of his course of training; and thirdly, these introductory courses will teach the student his limitations and give a greater incentive to master the more abstract sciences which are necessary in order to master the theory of naval architecture.

English should also start the first year and continue throughout the four years. The students' experiences and observations in his outside work will make excellent subjects for compositions and take away much of the antipathy that the student has for this subject.

Aside from these two considerations the present lay out of the freshman year in most engineering schools fulfills the needs of the first year of a course in naval architecture. In arranging the course, however, the practical work just completed and the summer work to follow should be kept in mind; so that the outside time will be spent to the best advantage.

The second year should follow more or less the same outline as given in the course of naval architecture at the Massachusetts Institute of Technology. More professional work, however, should be included and a systematic study of naval architecture and ship construction should commence.

By the time the student reaches his third year he should be familiar with the principles of ship construction, the drawing and fairing of ship's lines, and the making of half models. He should also have covered the elements of naval architecture and general engineering.

The third year should start out with a technical study of ship design and the more advanced study of naval architecture. About the middle of the third year an actual problem in ship design should be started which should continue through until the end of the fourth year and parallel the theoretical work of the course. This problem should consist of selecting of the proper proportions and dimensions to meet an assigned condition. It should start with a preliminary estimate of weight, stability, power, etc. Next a preliminary set of lines and arrangement plan should follow. Finally, a certain amount of the construction plans should be drawn and the final calculations for weight, trim, stability, displacement and power carried out.

It is extremely important that coefficients and data from good practice be available and the student taught to apply these to his design.

This problem cannot be carried through as it would be in practice because many of the subjects will not always be taken up in class in time to be worked into the problem at their proper sequence.

The following subjects should be worked into the problem and illustrated by examples from practice: tonnage, freeboard, location of bulkheads and flooding of compartments; cargo and deadweight capacities, and Lloyds or similar construction rules; longitudinal strength and rolling period; stern lines and propeller bossing. Consideration should be given the power and propeller calculations and careful attention paid to the proportions of the boat, number of screws and revolutions of the engine for the most economical performance of the ship in service.

The course in marine engineering should take up such subjects as the selection and arrangement of the propelling machinery and auxiliaries; the heating surface, evaporation and fuel consumption of the boilers for a given steam consumption. After these points have been incorporated into the problem a consideration should be given to the economics of steam engineering. This should cover such subjects as fuel consumption for various types of propelling machinery, boiler economy, feed heaters, economizers, effect of leaky condensers, etc. These are all problems given careful attention in power plants on shore but too often overlooked on shipboard. A good naval architect should be well versed in steam engineering and should be taught to study the economical problems of the machinery as well as those of hull design.

Other subjects covered in the third year should include advanced mechanics, steam engineering and laboratory, electrical engineering, hydraulics, metallurgy, English, and economics of engineering.

In the fourth year the design problem should continue and the more advanced parts of theoretical naval architecture taken up. Some attention should also be given to heating and ventilation and aëronautics. A considerable portion of the year should be given over to marine engineering, including engine design, steam turbines, boilers and diesel engines. The importance of studying these subjects from the economic point of view has already been mentioned.

By the fourth year the student should be able to choose for himself what division of the field of naval architecture he hopes to follow. Highly specialized options in ship design, shipbuilding, and ship operation should be introduced in the last year. This should be the only place in the course, however, where specialization is allowed, for the young engineer can seldom foresee what trend his career is likely to take.

In addition to the subjects mentioned, some time should be given in the training to yacht design, for its value in teaching the form and ''sweetness'' of ship's lines; and to cover the essentials of this field in case a student elects it as his life's work.

The course in economics after covering the fundamentals of the subject should take up concrete problems in connection with the work in naval architecture. Such a problem as steam vs. diesel engines for a given trade route and given vessel could be discussed with regard to first cost, ability to obtain a supply of fuel oil, cost of operation, depreciation, repairs, etc. Or again, a problem on the size of ship for a certain trade could be taken up and such points as interest on investment, time required in port for loading and unloading, and opportunity to obtain a cargo, considered.

Such a course would require coöperation between the instructors in economics and naval architecture and talks by men actually engaged in shipping. The department of naval architecture could also introduce at this time the economic consideration of the design problem already underway.

The foregoing briefly outlines the field that should be covered for a training in naval architecture. Before concluding I wish to add a few remarks as to the method of presenting the work. Too many of our engineering schools attempt to cover too much ground; and the result is that the student graduates with a rather confused conception of the various subjects treated instead of a strong working framework on which to build. The courses, I believe, should be so taught that the main points are forcibly brought home and inculcated upon the student's mind; and the less essentials treated in a more cursory manner for the student to master at his own convenience as future occasions may demand. First he should receive a strong foundation and framework in the basic principles and theory with as much amplification and explanation as the time available will allow. Then he should receive careful instruction how to build on this foundation and how to go about filling in the framework by study and reading after graduation.

Great care should be taken to see that the courses are properly interrelated; so that the student sees the connection and transition from one subject to another and is able to apply the basic sciences to his professional work. An excellent way to do this is for the department of naval architecture to take the student as soon as he has finished a course in mathematics, physics, mechanics, etc., and put him through an intensive review of the more important parts, and parallel this review with problems in naval architecture and ship construction. For example: The course in mechanics should be reviewed in this manner and those points that have any bearing on naval architecture or marine engineering should be forcibly brought home to the student; and problems on strength and support of deck beams, bulkhead stiffening, longitudinal shear in a ship's structure, and the like, assigned. This method instills in the student a clearer understanding by presenting the subject from an entirely new standpoint.

Before graduation problems should be assigned that will cover the work of several subjects in one problem. These problems will not only test the student's knowledge of the whole course of training but also his common sense, judgment and ability to tackle original problems. For example, a problem on the electrical steering gear for a given ship could be assigned. This would require a knowledge of rudders, the steering and maneuver of ships; the friction of mechanism, the computation of the power for the steering engine; an investigation of the torque and efficiency of electric motors, and the selection of the proper type of motor for the work.

These suggestions for a course in naval architecture will tend to produce a course that is more practical and purely professional than the general run of engineering courses at present offered. For this reason, it is very essential that purely educational subjects, as history, English literature, and economics be included in the training. The instructors in these subjects should be men of broad education and high ideals; so that the student will have the other side of his character developed by association with men of such quality. For the same reason athletics and other student activities should be encouraged. We must not lose sight of the fact that the graduate should be a leader in the world; one able to meet and sympathize with the problems of the day, as well as to carry on the technical work of naval architecture.

The course of training that I have presented is rather a departure from the present accepted courses given in this country. We should bear in mind, however, that this country is just entering the field of maritime commerce in which other nations are well established. At the outset, we are hampered by labor conditions and seamans' laws that put us at a disadvantage with our competitors. For us to compete successfully with them under these conditions, it is necessary that we design more efficient ships and build and operate them in a more efficient manner. The men who are to carry out this work must be trained in the broadest and most rigid manner. The course that I have outlined was planned with this object in view.

With a course of training as suggested, the student will enter college with a clearer knowledge of his own qualifications, and the scope of his profession; he will pursue his studies with a more appreciative attitude, and will recognize far better the application of theory to practice; he will leave school with a strong framework of the theoretical, economical and practical branches of naval architecture; and he will have a clearer vision of his future, a more definite purpose, and a more intimate personal knowledge of what is required of him in the industrial world, than the graduates of the past.

PROGRAM OF THE JOINT MEETING OF THE BRITISH EDUCATIONAL MISSION AND THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

The Secretary received, during the latter part of September, a letter from the Committee for the reception of the British Educational Mission of the American Council on Education, asking the Society to consider holding a joint meeting with the British Educational Mission, December 6–7. The Committee suggested the following topics for discussion: "The Organization of Technical Education in Great Britain and the United States," "The Effect of the War on Technical Education in Great Britain and the United States," and "The Liberal Element in Technical Education." President R. C. MacLaurin offered on behalf of the Massachusetts Institute of Technology to act as host in case such a meeting could be arranged. These topics together with the dates were approved by a vote of the Council.

The Program Committee then prepared the following program, copies being sent to each member of the Society, delegates, presidents of institutions, and others interested in the meeting:

Friday, December 6.

2 P.M.

Opening session, Massachusetts Institute of Technology, Cambridge—President John F. Hayford presiding.

Address of Welcome on behalf of the Massachusetts Institute of Technology. R. C. MacLaurin, president, Massachusetts Institute of Technology.

Address of Welcome on behalf of the Society for the Promotion of Engineering Education. John F. Hayford,

president, Society for the Promotion of Engineering Education.

Response to Addresses of Welcome. British Educational Mission to the United States.

The Organization of Engineering Education in Great Britain. Sir Henry Miers, British Educational Mission to the United States.

The Organization of Engineering Education in the United States. Charles S. Howe, president, Case School of Applied Science, Cleveland, O.

Discussion.

7 P.M. Dinner.

SATURDAY, DECEMBER 7.

10:00 A.M.

Morning session, Rogers Building, Boston—President Hayford presiding.

The Effect of the War on Engineering Education in Great Britain. Dr. John Joly, British Educational Mission to the United States.

The Effect of the War on Engineering Education in the United States. C. R. Mann, Massachusetts Institute of Technology.

The Training of Engineers for the U. S. Army. Gen. Wm. M. Black, Chief of Engineers, U. S. Army.

Discussion.

12:30 P.M. Luncheon.

2:00 P.M.

Afternoon session, Rogers Building, Boston—President Hayford presiding.

The Liberal Element in Engineering Education. Rev. Edward Mewburn Walker, British Educational Mission to the United States.

The Liberal Element in Engineering Education. George F. Swain, professor, civil engineering, Harvard University.

Discussion. Adjournment.

MEMBERS OF THE MISSION.

Dr. Arthur Everett Shipley, vice-chancellor of the University of Cambridge, master of Christ's College and reader in zoölogy.

Sir Henry Miers, vice-chancellor of the University of Manchester and professor of crystallography.

The Rev. Edward Mewburn Walker, fellow, senior tutor, and librarian of Queen's College, member of the Hebdomadal Council, Oxford University.

Sir Henry Jones, professor of moral philosophy, University of Glasgow.

Dr. John Joly, professor of geology and mineralogy, Trinity College, Dublin.

Miss Caroline Spurgeon, professor of English literature, Bedford College, University of London.

Miss Rose Sidgwick, lecturer on ancient history, University of Birmingham.

DELEGATES.

Armour Institute of Technology, Chicago, Ill., Professor Howard Raymond.

Akron, University of, Akron, Ohio, Dean Fred E. Ayer.

Brooklyn Polytechnic Institute, Brooklyn, N. Y., President F. W. Atkinson, Dr. Samuel Sheldon.

Brown University, Providence, R. I., Professor W. H. Kenerson, Professor J. E. Hill.

California, University of, Berkeley, Cal., Major C. G. Hyde.

Carnegie Institute of Technology, Pittsburgh, Pa., President A. A. Hamerschlag, Dean W. E. Mott, Professor W. V. Bingham.

Case School of Applied Science, Cleveland, O., President Chas. S. Howe.

Cincinnati, University of, Cincinnati, O., Professor A. M. Wilson.

Colorado School of Mines, Golden, Col., President V. C. Alderson.

Colorado, University of, Boulder, Col., Dean Milo S. Ketchum.

Columbia University, New York, N. Y., Professor G. B. Pegram, Professor M. I. Pupin.

Committee on Education and Special Training, War Department, Brigadier General R. I. Rees.

Cornell University, Ithaca, N. Y., Professor D. S. Kimball.

Delaware College, Newark, Del., President S. C. Mitchell.

Drexel Institute, Philadelphia, Pa., President Hollis Godfrey, Professor Ira W. Fisk.

Harvard University, Cambridge, Mass., Professor A. E. Kennelly, Professor G. C. Whipple, Professor H. J. Hughes.

Iowa State College, Ames, Iowa, Dean Anson Marston.

Iowa, State University of, Iowa City, Ia., Dean W. G. Raymond.

Johns Hopkins University, Baltimore, Md., Professor C. J. Tilden.

Kansas State Agricultural College, Manhattan, Kan., President W. M. Jardine, Dean A. A. Potter.

Kentucky, University of Lexington, Ky., President Frank L. McVey, Dean F. P. Anderson.

Lafayette College, Easton, Pa., President J. H. MacCracken, Professor A. H. Fuller.

Lehigh University, South Bethlehem, Pa., Professor F. P. McKibben.

Leland Stanford Jr. University, Stanford University, Cal., President R. L. Wilbur, Professor C. D. Marx.

Maine, University of, Orono, Me., President R. J. Aley, Dean H. S. Boardman.

Massachusetts Institute of Technology, Cambridge, Mass., President R. C. MacLaurin, Professor W. T. Sedgwick.

McGill University, Montreal, Can., Professor J. B. Porter.

Michigan Agricultural College, East Lansing, Mich., Dean G. W. Bissell.

Michigan, University of, Ann Arbor, Mich., Professor J. R. Nelson.

Michigan College of Mines, Houghton, Mich., President F. W. McNair.

Minnesota, University of, Minneapolis, Minn., President M. L. Burton, Dean Jackson, Dean J. R. Allen.

Missouri, University of, Columbia, Mo., President A. Ross Hill, Dean E. J. McCaustland.

Nebraska, University of, Lincoln, Neb., Dean O. J. Ferguson.

New Hampshire College, Durham, N. H., Dean C. E. Hewitt.

New York University, University Heights, N. Y., Dean C. H. Snow, Professor W. R. Bryans.

Northwestern University, Evanston, Ill., Director J. F. Hayford, Professor H. Crew.

North Carolina, University of, Chapel Hill, N. C., Professor R. H. Doggett.

North Dakota, University of, Grand Forks, N. D., Dean E. J. Babcock.

Oklahoma, University of, Norman, Okla., Professor L. W. W. Morrow.

Ohio State University, The, Columbus, O., Professor Wm. T. Magruder.

Pennsylvania State College, State College, Pa., Dean R. L. Sackett.

Pennsylvania, University of, Philadelphia, Pa., Professor R. H. Fernald.

Pittsburgh, University of, Pittsburgh, Pa., Chancellor S. B. McCormick, Dean F. L. Bishop.

Princeton University, Princeton, N. J., Professor F. H. Constant.

Purdue University, LaFayette, Ind., President W. E. Stone.

Rhode Island State College, Kingston, R. I., President Howard Edwards, Professor R. L. Wales, Professor S. H. Webster.

Rose Polytechnic Institute, Terre Haute, Ind., President C. H. Mees, Professor John White.

Rutgers College, New Brunswick, N. J., Professor F. F. Thompson.

Sheffield S. School—Yale, N. Haven, Conn., Director R. H. Chittenden, Professor J. C. Tracy.

Stevens Institute of Technology, Castle Point, N. J., President A. C. Humphreys.

Syracuse University, Syracuse, N. Y., Dean W. P. Graham.

Throop College of Technology, Pasadena, Cal., Professor A. H. Fleming.

Tufts College, Tufts College, Mass., Dean G. C. Anthony, Professor E. H. Rockwell.

United States Naval Academy, Annapolis, Md., Commander J. L. Hileman.

University of Vermont, Burlington, Vt., Dean J. W. Votey.

Washington University, Saint Louis, Mo., Dean A. S. Langsdorf.

Wentworth Institute, Boston, Mass., Principal A. L. Williston.

West Virginia, University of, Morgantown, W. Va., President F. B. Trotter, Professor J. N. Beahl, Professor O. P. Chitwood.

Wisconsin, University of, Madison, Wis., Dean F. E. Turneaure.

Worcester Polytechnic Institute, Worcester, Mass., President Ira N. Hollis, Professor A. L. Smith.

American Chemical Society, Washington, D. C., Dr. H. P. Talbot.

American Institute of Chemical Engineers, New York, N. Y., Professor J. R. Withrow, Mr. A. D. Little.

American Society of Civil Engineers, 33 W. 39th St., N. Y., Dr. G. F. Swain.

American Institute of Electrical Engineers, 33 W. 39th St., N. Y., Dr. Samuel Sheldon.

American Institute of Manufacturing Engineers, 29 W. 39th St., N. Y., Professor Robt. H. Richards.

American Society of Mechanical Engineers, 29 W. 39th St., N. Y., Professor Clifford B. LePage.

The opening session was held Friday, December 6, at 2:00 P.M. in Room 3–370, southwest wing of the Massachusetts

Institute of Technology, in Cambridge, with President John F. Hayford presiding.

President R. C. MacLaurin welcomed the guests and members of the Society on behalf of the Massachusetts Institute of Technology. President John F. Hayford welcomed them on behalf of the Society for the Promotion of Engineering Education. Dr. Arthur Everett Shipley, vice-chancellor of the University of Cambridge, master of Christ's College and reader in zoölogy, responded to the addresses of welcome on behalf of the members of the British Educational Mission. Unfortunately the members of the British Educational Mission had to leave Boston on Saturday morning and could not, therefore, attend the Saturday sessions. Because of this the addresses by them scheduled for Saturday were delivered on Friday. Meeting adjourned at 4:30.

The Saturday sessions were held in Huntington Hall, Rogers Building, Boston. The morning session was called to order at 10:00 A.M., with President John F. Hayford presiding. The papers, "The Organization of Engineering Education in the United States," by Chas. S. Howe, president, Case School of Applied Science, Cleveland, Ohio, and "The Liberal Element in Engineering Education," by George F. Swain, professor of civil engineering, Harvard University, Cambridge, Mass., were read by title. Dr. C. R. Mann delivered an address on "The Effect of the War on Engineering Education in the United States." General William M. Black delivered an address on "The Training of Engineers for the United States Army." These papers were then discussed. Motion was made and carried that the afternoon session be devoted to the discussion of the reconstruction problems and the bills pending before Congress regarding the engineering experiment research stations.

The afternoon session was called to order at 2:30 P.M. by President Hayford. The meeting was devoted to discussion.

There were one hundred and twenty-three members and guests registered at the meeting. Those registering are:

Frank C. Allen, Gardner C. Anthony, Victor C. Alderson, Frank Aydelotte, F. L. Bishop, G. W. Bissell, Wm. M. Black, G. F. Blessing, H. S. Boardman, Wm. R. Bryans, A. E. Burton, Samuel P. Capen, Lawrence B. Chapman, Norman Collyer, F. H. Constant, Henry Crew, P. H. Daggett, C. R. Dooley, O. J. Ferguson, J. W. Dietz, R. H. Fernald, Chas. E. Ferris, Ira W. Fisk, Desmond FitzGerald, W. S. Franklin, Almon H. Fuller, Lillian M. Gilbreth, Frank B. Gilbreth, Hollis Godfrey, H. M. Goodwin, Louis T. Grant, C. E. Haigler, Miss Sada A. Harbarger, John F. Hayford, H. W. Hayward, Chas. E. Hewitt, Jas. L. Hileman, John E. Hill, H. O. Hofman, Elmer A. Holbrook, Chas. S. Howe, Hector J. Hughes, Charles G. Hyde, S. G. Johndroe, John Joly, Wm. H. Kenerson, Arthur E. Kennelly, Dexter S. Kimball, Carl King, Albert Kingsbury, Howard S. Knowlton, A. S. Langsdorf, J. S. Lapham, Ralph R. Lawrence, F. A. Laws, Clifford B. LePage, E. J. McCaustland, S. B. McCormick, Miss Nell (Mrs.) McKenry, R. C. MacLaurin, Wm. T. Magruder, C. R. Mann, Anson Marston, C. D. Marx, K. G. Matheson, C. L. Mees, Sir Henry Miers, Samuel C. Mitchell, L. W. W. Morrow, William E. Mott, J. Raleigh Nelson, Arthur E. Norton, J. C. Olsen, Henry G. Pearson, George B. Pegram, Ellwood C. Penisho, J. B. Porter, A. A. Potter, Donald B. Prentice, M. I. Pupin, H. M. Raymond, W. G. Raymond, Lepine H. Rice, Robert H. Richards, W. H. Richards, C. W. Ricker, W. M. Riggs, Edward Robinson, Edward H. Rockwell, W. S. Rodman, R. L. Rohrer, R. L. Sackett, Chas. F. Scott, W. T. Sedgwick, Geo. C. Shaad, Samuel Sheldon, Arthur Everett Shipley, Alton L. Smith, Charles H. Snow, Henry P. Talbot, Frank F. Thompson, James S. Thompson, W. O. Thompson, Charles J. Tilden, William H. Timbie, J. C. Tracy, F. E. Turneaure, H. W. Tyler, Mrs. W. L. Upson, W. L. Upson, Edy Velander, J. W. Votey, R. L. Wales, Rev. Edward Newburn Walker, Harrison E. Webb, S. H. Webster, W. C. Whitney, George C. Whipple, Raymond L. Wilbur, W. O. Wiley, Arthur L. Williston, A. M. Wilson, Stanley A. Zweibel.

JOINT MEETING WITH BRITISH EDUCATIONAL MISSION.

An informal dinner was tendered the members of the British Educational Mission on Friday evening in the Hotel Brunswick. There were eighty-seven present at this dinner. On Saturday evening an informal meeting was held in the Hotel Brunswick, at which there was a general exchange of ideas on various topics now confronting the engineering schools. Twenty-eight members attended this meeting.

EDITORIALS.

The special meeting of this Society held in conjunction with the British Educational Mission was in many ways of interest to those who attended, not only on account of the excellent papers and addresses which it was their privilege to hear, but also from the fact that the many questions confronting all engineering schools are such that each man desired to secure the personal opinions of many other teachers of engineering in regard to the problems. It was unfortunate that Professor George F. Swain was called to France just before this meeting. As a result of this his paper on "The Liberal Element in Engineering Education," which appears in this number of the BULLETIN, was read by title. It is not often that this Society has the privilege of having presented to it papers of the character of those at this meeting. The two papers published in this number of ENGINEERING EDUCATION and those that will appear in the January and February numbers are well worth the attention of not only the individual members of this Society, but of the faculties of the schools of engineering in this country.

The Council of the Society voted at the beginning of the war to exempt from dues all members entering service. This together with the other conditions familiar to everyone has led to a considerable decrease in the income of the Society. It is, therefore, imperative that every member should make it a point to secure at least one new member in order that the growth and financial condition of the Society may continue as in the past. If you know any member of your faculty who should be a member, will you send his name to the Secretary?

THE OFFICERS OF THIS SOCIETY HAVE OPPOSED INCREASING THE DUES, ALTHOUGH IT HAS BEEN SUGGESTED BY VARIOUS MEMBERS AT DIFFERENT TIMES. IF EVERY MEMBER PAYS HIS DUES PROMPTLY THERE IS NO NECESSITY FOR SUCH ACTION. IF YOU HAVE OVERLOOKED THIS MATTER, WILL YOU NOT ASSIST THE SOCIETY BY SENDING YOUR CHECK TO THE TREASURER, MR. W. O. WILEY, 432 FOURTH AVENUE, NEW YORK CITY?

COLLEGE NOTES.

The Pennsylvania State College.—One of the engineering buildings at The Pennsylvania State College was recently destroyed by fire, affecting the Departments of Industrial and Mechanical Engineering. A new building was just being completed and a second one has just been begun. Temporary provision has been made for a forge shop and the steam engineering laboratory. Plans for permanent buildings are being considered.

Sheffield Scientific School, which has been since its inception practically a three-year school, has decided beginning with next year to go on the four-year basis.

SOCIETY NOTES.

The BULLETIN and the PROCEEDINGS have been delayed due to the fact that the printers were in quarantine for several weeks on account of the Spanish influenza. It is hoped that the January BULLETIN will appear on time since the material is now in the hands of the printer.

The Proceedings of the Northwestern meeting are in page proof and the volume should be ready for mailing during the month of January.

The March number of the BULLETIN of this Society has been the year book. It is an expensive number to issue and for this reason the Council at the Northwestern meeting directed the officers not to issue the complete year book during the present year but to publish in the March number the changes of titles and addresses of the members. Will you assist us by sending in not only your own changes but any others which you may know have occurred since the last issue of the year book?

This Society is an affiliated society of the American Association for the Advancement of Science and coöperated with the officers of Section D in arranging for the program at the Baltimore meeting, December 26 and 28. The following papers were presented: "The Need of Conservation of Our Vital and Natural Resources as Emphasized by the Lessons of the War," by Henry S. Drinker; "Intensive Training," by C. R. Dooley; "The U. S. Naval Engineering Experiment Station," by Mr. DeBaufre; "Hydraulic Tunneling," by F. J. Trumpour; "The Corona Voltmeter," by J. B. Whitehead; "The Metric System Used in Engineering," by F. A. Halsey. L. A. Doggett, professor of electrical engineering at the U. S. Naval Academy, acted as local secretary and was responsible for the excellent way in which the meeting was conducted.

The Society has received an invitation from The Johns Hopkins University to hold the 1919 meeting at that institution. The Council has taken no action in regard to the next annual meeting. It has been suggested that a large part of the time of the next annual meeting be devoted to the discussion of the Mann report of the Joint Committee on Engineering Education. A special committee of this Society consisting of W. E. Mott, C. S. Howe, L. M. Hoskins, T. U. Taylor and F. H. Constant was appointed at the Northwestern meeting to consider the subject.

BOOK REVIEWS.

Elementary Mathematical Analysis. By CHARLES S. SCHLICHTER, Sc.D., Professor of Applied Mathematics, University of Wisconsin. Second Edition. xvii + 497 pages. McGraw-Hill Book Co., Inc. 1918.

In this edition "changes in order of material and method of treatment have been fully made," some new material has been added and many exercises have been omitted. A separate chapter has been given to the Power Function. Some very good suggestions to students are given in the Introduction on the methods of study of Mathematics. It seems that this is a thing that should be given more attention than it has received in the past and that any text book should contain information of this character.

This book seems to be a correlation of mathematics, but the real test of any such book must be the class room. Some books which attempt to correlate have lost unity and clarity in the manner of treatment. We must not forget that a chapter or even a paragraph that is not "unified or correlated" is much worse pedagogically and psychologically than a book the chapters of which are not so related, and the latter book is worse than a set of books not so related. Instead of dispelling the clouds some books have only succeeded in creating a mist. This criticism is not aimed at the present work, but is merely mentioned to point out to us that many attempts will be made to write a modern book on mathematics while only a few authors, perhaps one or two, will succeed in bringing forth a work that will stand the test of several years in the class room under able instructors but who also may have varying methods of instruction.

F. A. F.

The Chemical Analysis of Iron. By ANDREW A. BLAIR. Eighth edition. 318 pages. 1918. J. B. Lippincott Company, Philadelphia, Pa.

Thirty years ago Blair published "The Chemical Analysis of Iron,'' and no one book has dominated more the determination of the constituents of iron and steel.

The eighth edition differs from the seventh in that a great part of it has been recast and rewritten to include improvements in the methods for the determination of the different elements in iron, steel and the ferro alloys. The various methods for each constituent have been grouped together. The factors have been recalculated for the latest atomic weights. The chapter on the analysis of furnace and other gases has been omitted. The chapter on coal analysis has been retained from previous editions. The methods are those recommended in 1899 by the committee on coal analysis for the American Chemical Society. The new methods for coal analysis published in January, 1917, by The American Society for Testing Materials, The American Chemical Society and The American Institute of Chemical Engineers are not mentioned. This edition has but five references to the literature later than the sixth edition.

From the standpoint of engineering education, to train chemists and not to make iron and steel analysts who are not chemists; the place for this book is the reference library. Its sub-title, ''A Complete Account of All the Best Known Methods . . . ,'' gives its scope and its limitations. Usually the methods are given with a wealth of detail on laboratory manipulation and technic; but this book was not designed to teach the chemistry underlying the method. The mastery of this book by the student brings no assurance that he will be able to devise a new method or know which of the given methods may best be used. The rearrangement of the material in this edition gives it increased value as a reference book of methods.

L. E. J.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

Vol. IX LANCASTER, PA., JANUARY, 1919 No. 5

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INTRODUCTORY REMARKS.

JOINT MEETING OF BRITISH EDUCATIONAL MISSION TO THE UNITED STATES AND THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS., DECEMBER, 6–7, 1918.

President John F. Hayford: The meeting will please come to order. I ought to tell you, perhaps, at the outset that this meeting was called at the request of the Committee on International Relations of the American Council on Education; the meeting was called at the request of that committee.

It was called as a joint meeting of the British Educational Commission and the Society for the Promotion of Engineering Education. The committee also selected the three topics which you find on the program as the topics of the meeting; the dates were also selected by that committee—all the preliminary arrangements, in other words.

I believe the first thing on our program is the address of welcome by Dr. R. C. MacLaurin, President of the Massachusetts Institute of Technology, Dr. MacLaurin.

ADDRESS OF WELCOME ON BEHALF OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

BY PRESIDENT R. C. MACLAURIN.

Mr. President, Ladies and Gentlemen: It is a pleasure on the part of the Institute to welcome such a gathering as this at any time, but particularly under the circumstances of the place and time.

We are here to welcome the British Educational Mission, and we welcome them while we are looking out on the Charles River, named in honor of an English king who, among his other accomplishments, helped to form the Royal Society, the society which did so much for all the fundamental sciences in which all real engineers are so vitally interested. Of course we are in the city of Cambridge, which carries with it all the associations which cluster around Harvard University.

It is with extreme pleasure we welcome you to this institution, which is bound by a thousand ties to engineering institutions all over this country and in Great Britain; and if the place is propitious the time is especially so. We are practically at the end of a great war and at the beginning of a new period of history; a great war that has demonstrated more dramatically than anything else could have demonstrated the enormous importance of applied science in all the activities of life, and has brought home to everybody the fact that in peace as well as in war the very existence of nations will depend upon the extent to which they realize the usefulness of science.

The problems of engineering education which you are going to discuss are, in a certain sense, new problems, because the world is, in a certain sense, new; but I for one will be surprised if they do not prove to be rather old problems, because the matters usually discussed at all these meetings are always old—the old question, for example, of how to deepen and broaden the training of an engineer.

As the years roll by we all appreciate the increased importance of his education, and always there is the call for the broader man and the deeper man in the engineering profession, and how to make him broader and deeper is the root problem. And there is always the same divergence of view and the same concurrence of view on certain matters regarding the fundamental problems; and these problems are really similar in all parts of the world, so that I confidently expect that what our honored guests from Great Britain will tell us will be directly applicable to our conditions here.

Unfortunately, as I have just learned, they are to leave the city tomorrow morning, and that necessitates a change of the program and calls for the utmost brevity in introductory remarks; so without trespassing further in that direction I offer to you in the name of the Massachusetts Institute of Technology a most cordial welcome to the British Mission and to this Society for the Promotion of Engineering Education.

ADDRESS OF WELCOME ON BEHALF OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

BY JOHN F. HAYFORD, PRESIDENT.

According to the printed program it now falls to me as president of the Society for the Promotion of Engineering Education to express to our friends from Europe the welcome of that society. That is a welcome then to representatives of higher education—all forms of higher education in Great Britain from the representatives of engineering education in the United States.

We welcome our British friends as brothers—if not brothers, at least they are the descendents of certain brothers who decided some years ago to stay at the old homestead in England, and we are the descendents of brothers who tried the experiment of planting British ideas of a new sort. And to you members of the Great Britain branch we extend a welcome; we are glad to exchange ideas with you; we put forth our ideas with confidence, because we feel that if you find in our ideas anything good you will credit it to us. If you find in our ideas anything which you cannot approve, we depend on you to charge it to the poor soil in which those British ideas were planted, a century or two ago.

We would like to get as near as possible to a real interchange of ideas—a meeting of two groups of mind. I feel, perhaps, that I should introduce to our British friends this Society for the Promotion of Engineering Education. The society was born at an international gathering at the World's Congress at the Chicago Exposition in 1893, and has grown steadily to about ten times its original number, starting with about 150 members and now has 1,500, and contains representatives of over 200 educational institutions. A large proportion of our membership comes, of course, from the United States, with widely scattered homes from the Atlantic to the Pacific, and from Canada to the Gulf.

It is interesting on the present occasion to note that we have in the Society thirty-two members from Canada, seven members from Australia, four members from India, and two members from England itself. This society was the first in the world to organize for the promotion of engineering education, and so far as I know it is at present the only society of that kind.

Now, in the United States we have a number of strong societies dealing with education, especially a number of strong societies dealing with higher education; but this society, so far as I know, is the only one in the United States dealing with a special form of education. If I stop with that form of statement it might appear that this society looks at education from a narrow and restricted point of view. The fact is, however, that the Society for the Promotion of Engineering Education has habitually considered its problems on a very broad basis. The prevailing idea of this society is that our business is to train men for service as engineers. To understand the views of this society I think it is necesary for you to keep in mind we consider engineering is a profession rather than a trade, and therefore that we believe the proper form of engineering education is one which trains for a profession which is at least as high in its requirements as the law, medicine or the ministry. We consider that in a trade one offers skill to the world, and that in a profession a man offers to the world his expert knowledge.

We do not consider that it is primarily our business in engineering education to give a man skill in the shop, in the laboratory or in the construction-camp. On the other hand, we believe the primary purpose of engineering education is to develop a sound basis for such expert knowledge in the future that the engineer may well direct others in utilizing the forces of nature for the benefit of man. The development of skill belongs in the trade schools, which we sadly lack in this country—lack in numbers, at least; and in this society as a consequence there are too few representatives of the trade schools. The development of the germs of expert knowledge applies to colleges of engineering of the type which this society would like to see developed.

The distinction between skill and expert knowledge, it may be clearly seen, leads to a differentiation in various places in the program of education of the two kinds.

I would like to turn aside to another line of thought for a moment. A man while speaking usually or often has trouble to control himself in such a way as to say the things which on riper reflection he will realize were the things best to be said at that time. It is still more true in a meeting like this that one has a similar difficulty.

Just at the present moment this society is likely to have difficulty in controlling itself as to what shall be the proceedings of this series of meetings. There are abundant opportunities to spend time on the little details and miss the main points; especially just at present there is a strong temptation before us to talk of the recent and temporary troubles due to the war experiences which we have just been going through. It seems to me it would be a misfortune for this meeting to spend much time in dealing with those temporary matters. I hope, therefore, that I shall have your coöperation from the floor if you find I exhibit a tendency to try to steer toward the main points and to avoid spending time on our temporary troubles.

It seems to me the three topics chosen for this meeting are especially fit for the occasion, and I say that because I did not have anything to do with selecting those topics. It is obviously important that we should discuss now the effect of the war upon education. Under the stress and stimulus of war we have just tried educational experiments, and we have had to make various changes. Now while the facts are still fresh in our memories is the proper time to discuss the larger features of those matters, to bring out the points which may help us in future work. Some of the things that have been done should be retained; possibly out of our experience will grow some new things, and attempts we have not tried to change recent experience may suggest.

It is then clearly right that we should concentrate a part, at least, of this meeting in considering what new departure should be made from our new experience.

When I looked at the topic, ''The Organization of Engineering Education in the United States,'' it has occurred to me that the fact is we have something more than six score colleges of engineering in the United States, each legally independent of the other, and that the principal bond which ties them together is this Society for the Promotion of Engineering Education, which meets once each year when we discuss our prominent problems.

The topic, ''The Liberal Element in Engineering Education'' is at home in this society. One of the things that attracted me to this society was the discussion indicative of an aspiration for the more liberal education for engineers than that in vogue in our American universities and in the parts of universities devoted primarily to a liberal culture. Those aspirations on the part of the society are to me the thing, or one of the things, that give to the association its flavor.

Recalling President MacLaurin's remark about the shortness of the time, I am also reminded that when I consulted the little demon of the inner recesses of my mind, to whom I would go for instruction, and especially with regard to this meeting—I had some trouble in getting any response from him; but finally, after I insisted, with much squirming he said, ''Well, at any rate you can so conduct yourself that afterward they will remember of your talk that brevity was the soul of it.''

RESPONSE TO ADDRESSES OF WELCOME.

BY ARTHUR EVERETT SHIPLEY,

Vice-Chancellor of the University of Cambridge, Master of Christ's College and Reader in Zoölogy.

Ladies and Gentlemen: I begin with a word of thanks to you for receiving us, and we greatly appreciate the honor of being here. And then I must follow that with a word of apology, for owing to some mishap we shall not be able to be with you to-morrow. We are traveling in your country very much as representatives of the dramatic agencies travel; our time is not our own, we have not made our own arrangements; we go hither and thither as told, and all I can say of the mistake that has arisen is what the schoolboy said when the school inspector asked him who wrote Hamlet—"Please, sir, I didn't."

Then I must apologize for the absence of Sir Henry Jones. I am sure you will understand when I state to you that of his three sons one has been killed, one is a prisoner in the hands of the Turks, and the third having a month's leave from India, it was the only chance for his father to see him. Otherwise you would have had the pleasure of listening to a man of real eloquence.

With regard to the special meeting before us I can contribute but little; all I know is that in our university we attach great importance to a thorough grounding in science, and any man to get into our school of engineering has to pass a very stiff examination in mathematics.

I might perhaps tell you a little about our engineering school; it can be put into one word. It was a very flourishing school, but at the present moment it is ruined; the buildings left were turned into shell factories, with no students and no teachers.

It is appalling the number of fatalities in the air-craft service, particularly among the professors, and it is typical of families in England that a mother is left with only one surviving child out of a family of six.

That is the sort of thing that is going on in my country; I do not think that over here the conditions are fully realized as to what has happened in that little island we represent. For instance, those of you who have been in France lately will bear me out in saying that food conditions are much better than in England. I do not think it is realized that the English forces have been fighting on thirty fronts, and that the casualties have amounted to half a million more than those of our allies. Those things do not seem to penetrate into the American papers.

Well, we are comparatively used to it. I consulted statistics connected with the university and found that in the big War of the Roses we were not affected so much as in the revolutionary wars under Cromwell. Later on in the time of Napoleon their numbers went down again; not so low as now but very low indeed. At present we are depleted of students to such an extent that we have run down from 4,000 undergraduates to 400. My own class of fifty in June, 1914, dropped immediately to a lady, a Chinaman and a black man, and at the end of three terms they went away and I lectured the following three terms to a black man from Africa—and when the lanterns went down I didn't even lecture to him but to a couple of eyes and a row of teeth. I lectured because in an old university, with all its faults, we have a certain respect for tradition, and I didn't want it thought that my class had come to an end. Now we are picking up a little; the government has sent us a large number of men, and I appeal to you to let your young men coming from the front—those boys who missed their university education—give them a chance while they are across the Atlantic and send them to an university in France, Italy or Great Britain. We are prepared to have special short courses to meet their needs, and prepared to give diplomas at the end of one term or a more full certificate at the end of three, which I believe the college authorities in this country would count towards their college course. I think that is one way in which we can clearly help, because if those boys go to one of those universities they can be called back from England, and they cannot get short leave across the Atlantic—and I believe that would be as much as could be done to stimulate a constant, never-to-end amity and friendship between these two nations.

Getting to understand one another would be far more effective than any "league of nations." We have seen the "peace palace"; we have had Mr. Carnegie's magnificent building, vouched for by the Czar, and we have had Mr. Ford come over on his mission; but, believe me, most of those missions have been largely engineered by cranks, and I do not use the word *crank* in its engineering sense.

Let us get together and talk things over and be friends, and above all begin with the young men. I have been watching men the last thirty-five years, young men and boys, and it is the young men who develop into men. Again I thank you very much.

ADDRESS.

BY REV. EDWARD MEWBURN WALKER,

Fellow, Senior Tutor, and Librarian of Queen's College, Member of the Hebdomadal Council, Oxford University.

Mr. Chairman, Ladies and Gentlemen: It has been represented to me that it would be quite in accordance with the spirit of this gathering here this afternoon if I were to put before you some of the views that I ventured to put before another gathering yesterday morning. I was asked if I would do that with the assurance that the audience would be different, and I was told there would be very few people present this afternoon who heard me yesterday morning; but to those here who did hear me yesterday forenoon I tender my humblest apologies.

Now, the question of engineering education is quite clearly a question which is of much more importance here in America than it is at home; the very fact of your society being constituted to deal with that question is proof of that. We have no such society at home, I think I am safe in saying; and the reason why the question is of much greater importance in America than in England is due to the very simple fact that the profession is infinitely of more importance in America than it is at home, for there the difficulty is to find jobs for the men, and over here the difficulty is to find men for the jobs. It is the difference between an old country whose resources have long since been developed, and the new country where incredible resources are merely awaiting development.

Now, we have traveled a good deal in this country; by tomorrow evening I think we shall have covered in this country over 8,000 miles by train, river-boat and car; and in going about we have kept our eyes open. At the end of last week we were passing on a train through Texas, and everywhere about us there was oil; everybody was talking of oil. Then we came to a bit of the line where the predominant hue was a bright yellow, and we passed cars laden with sulphur, and we heard the marvellous and almost incredible story of that deposit of pure sulphur. We felt as we looked on the one hand and the other what was contemplated in Dr. Johnson's familiar words, "the potentiality of riches beyond the dreams of avarice." We felt all that was wanted there was population; all that was wanted there was engineers, and the wealth is yours.

But though the question of the education of engineers is a far more important question—a question which forces itself upon the public mind here in a way it does not upon us, and is a profession so much more vital to the country, the point I wish to make first is this: The point involved in this question of the education of engineers is a problem not confined to engineers of this country, nor to engineers in general; it is not confined to any one country, it is not confined to any one calling or profession, for what we have to deal with is the difference—as profound a difference as well could be conceived, between two ideals, two views of education—between the short view and the long view. Between the view of those who are able to look ahead and content to wait, and the view of those who refuse to look much beyond the end of their nose.

Now, this war in our own country—and I have no doubt it is the same here in America—has brought to the front a very old friend of ours, the practical parent. The practice in England is for the man to sit down and write to the *Times*. In America you don't do that, for there is too much matter in the papers to find space for correspondence.

The practical parent has succeeded in finding room, notwithstanding the shortness of paper, even in the *Times*, and the sort of question he has been asking is how it is possible in view of the income tax of ten shillings on the pound—how is it possible to waste the money to send sons to college to learn useless accomplishments? They must learn something of practical good to them in the particular profession they are going to embrace.

Now, those people know what they mean, and it is not at all difficult to interpret what they mean; what they mean is this: Their son is going to be a merchant; it is necessary to learn a foreign language. What is the foreign language to help him most in a particular branch of trade? Well, say, Spanish, which is a comparatively easy language to acquire. Very well, how far is he going in the study of Spanish? Shall he be allowed to read Don Quixote in the original or shall he learn to conduct a conversation with Spanish friends offhand?

Of course that comes very plainly in the case of engineering, and the case for the practical man there is the strongest possible case, because the technical knowledge required of the engineer will occupy so much of his time; he wants so much more of the difficult technicalities of a language than most people do. And your practical man will be brought to see that there are certain things that the engineer must learn.

He must learn mathematics up to a certain point; he must learn to express himself in English up to a certain point; it is possibly of advantage to learn foreign languages up to a certain point—and it is always up to a certain point, and it is resolutely determined that your engineer shall not learn anything beyond that certain point. That is the one view we are all familiar with.

But there is another view of education which is this, that the whole end of education is to give men good minds instead of poor minds; to free them from superstitions of every sort and kind. And what superstition is more degrading than belief in the verbal instruction of the textbook to enable them to reason, to criticise, to infer. That is the other view of education, and it is quite clear that in stating that view I am stating no case for the old humanities or the newer humanities.

It is not a defense of education in literature as opposed to education in science; it is a defense of every good form of education. It is a defense of the full and free study of any subject that is worth studying. It is a defense of physics as much as of Greek; for what we claim there is this, that the student shall be allowed to study that subject which appeals to him; not up to certain points but up to any points he pleases, and he shall study it in such a way as to clear his mind so to give him power of thought, of criticism, of inference; in a word, to give him a better mind, a better instrument than he started with.

Now, what I venture to claim is this, and I feel quite sure from what fell from you that that is the view all in this room share; that that is really the long view opposed to the short view—the view which in the long run is going to make better engineers; it is the view which in the long run is going to be the most practical—it is the view which will be the best.

But there is a case for the inclusion of the humanities, even in the education of the engineer; for while I do more than admit—I assert—that in any form of education worthy of the name the study of any subject that is worthy of study does enable, or may enable a man to think, does give him a better mind than before.

There are gifts which are peculiar to the humanities; I do not mean the older humanities, I mean humanities in the widest sense—the study of literature and all that literature means; the study, for instance, of philosophy.

Now, the great gifts the study of the humanities can impart, besides this general gift of thinking, are the gifts of imagination and sympathy. But, as I was saying yesterday morning, there is imagination—and imagination. There is the form of imagination which is of peculiar importance to the engineer, and that is the scientific imagination; but imagination in the general sense I suppose everyone would admit is more likely to be stimulated by the study of literature than by the study of natural sciences; and though it may be objected to that there is such a thing as the scientific imagination, no one has ever claimed that there is such a thing as the scientific sympathy.

Everybody in this room can see what is the value of the scientific imagination to the engineer, and precisely so because the scientific imagination is of such supreme importance to him in his work—in his calling. The engineer who is well educated—well educated in the sense of a wide education—is likely to prove in the long run the better engineer; but why, it may be asked, is imagination in the other more general and wider sense to be considered, and why is sympathy of importance to the engineer?

I think there are two reasons, maybe three, but two reasons are suggested, one of which is a reason peculiar to the man as an engineer; the other is one that applies to him not as an engineer but as a man.

Now, I suppose we are all agreed about one point, that in the next few years there is going to be a great deal of difficulty in adjusting claims of labor and capital. I can hardly think of any class of men more likely to be brought directly into touch with problems of that sort than the engineer.

Do you remember, and some of you will know, that Mr. Rhodes when he founded the Rhodes Scholarships provided that a certain number of marks in choosing the candidate were to be assigned to what he called "the quality of leadership." And whatever you may think about Mr. Rhodes, or about his will or foundation, no one will question that Mr. Rhodes knew the world and human nature, and no one will dispute that he was a successful man of business. His experience with business in the world taught him the value of that quality in business of leadership.

Now, for that quality of leadership is needed quite clearly these two gifts of imagination and sympathy. What is the fundamental difficulty in settling questions of dispute between masters and men, between employers and employed, between the claims of capital and labor? No one in this room could tell. It is the old, old difficulty, as old as the hills—one class putting itself in the place of the other; capital seeing the problem as labor sees it, and labor seeing the problem as capital sees it. The employer will never put himself in the place of the employe; he will never see the problem from the employe's point of view without these gifts of sympathy and imagination. And surely half of the present trouble in the world—three fourths I can say with confidence—of the trouble connected with labor questions in my country (it may be different here) but in my country I can say with confidence that three fourths of the difficulty arises from the fact that employers as a rule have had a bad education instead of a wide and liberal one; because their education has not been such as to develop within them these divine gifts of imagination and sympathy.

Gentlemen and ladies, that is the reason that applies to the engineer, but after all, no matter what scheme of education you may contrive for your engineer, no matter how narrow and practical it may be, no matter how short your view, there is one thing you cannot do; you cannot train your student into a mere engineer; you cannot prevent him being something over and above an engineer; you cannot prevent him looking forward to marrying and being the father of a family; you cannot prevent him from having relations with his neighbors as a citizen and friend; you cannot prevent him from some day having to face some great sorrow in his life. And if he is going to become a man; if he is going to discharge the duties of a father, of a friend, neighbor or citizen, how else is he going to do all that without these gifts of sympathy and imagination. And if he is called upon to bear some great trial is he likely to find that trial easy or hard to bear if his education in the humanities has brought him in contact with the master minds of all the ages?

Ladies and gentlemen, to those of you who heard me yesterday, I am going to offer one more apology. One of the most unpardonable of social offenses is to tell what you think to be a good story a second time to the same audience. Whether this story is good or bad you shall judge; I can only confess that I told it yesterday. Some years ago I chanced to be in

Paris, stopping at a hotel I used in those days always to stop at; an old-fashioned hotel with a real table de hôte, one long table where you never knew whom you would find next to you, but whoever it was you talked to him or her. In this case it happened to be to him, and he had come from a well-known university in the middle west, being abroad as secretary to an international conference on employment. And I was asking about his university, and he was telling me that in the faculty in which he studied, the faculty of history, there were thirty-eight professors. I dare say he used the term professor in a somewhat loose sense, but there were thirty-eight.

I told him I was a student of history, and at my own university a good many people studied history; and he looked appreciative, and that led me into the fatal trap. I was foolish enough to blunder next into the question whether at his university there were any professors or students in ancient history. Then he smiled with a fine compassion and said, ''At our university history is understood to begin with the rise of the industrial movement in America.''

Now, ladies and gentlemen, I will put to you this question, Do you think your engineer in the future is going to understand the rise and progress of the industrial movement in America if he knows no history before that movement began? And do you think he is more or less likely to be able to solve, to deal with, to handle the industrial problems that confront him, if his knowledge of history, if his sympathy and imagination reach or do not reach back beyond the opening years of the nineteenth century?

ADDRESS.

BY SIR HENRY MIERS,

Vice-Chancellor of the University of Manchester and Professor of Crystallography.

Mr. President, Ladies and Gentlemen: You were quite right when you said I was surprised to see this program last night, and to discover I was apparently expected to deliver an address on a subject upon which I had not thought at all, because the program, I am sorry to say, did not get into our hands until last night. I have come, quite unable to say anything about this particular subject; and I have prepared no notes, for I could not think of anything appropriate to be said on the present occasion. I think if I had had time to consider it, I should not have much to say about the present organization of education of Great Britain, because I take it that the whole educational prospect in Great Britain is faced with great changes now, and one does not know exactly what has been discussed at home since we left England nearly three months ago. But I am going to gather together a few impressions produced on my mind in our journey through the United States, qualifying only with this remark, that in visiting universities—and we visited a large number—we have been singularly unfortunate in the things which concern this meeting most, and us intimately, for two reasons—wherever we went we were unable to see the laboratories and in but few instances saw the students; we have not been able to criticize or witness teaching of a subject or hear the students' views on education, and it is very difficult to-day to compare with Great Britain.

It was still more unfortunate that wherever we went many students were absent on S. A. T. C. work, and there was the still more disastrous circumstance of the epidemic of influenza, which prevented our seeing, in many cases, what might have been viewed if that had not been the case.

As far as my experience in England—for I have only been at Manchester three years and only seen the working of the university under war conditions; and under those conditions the work has been as different there as it has been here. The majority of the students have been carried away from the engineering laboratories into actual war service, and of those who remain a considerable number are assisting in research connected with the war; and all the resources of the colleges have been devoted to practical problems connected with the war; so I am only able to speak of ordinary conditions there.

In London, several years before I went to northern England, the question of engineering education was a difficult one because of abnormal conditions. During the whole of my time there I was engaged on a report on the University of London and revising many of the details as to how education could be organized in that extraordinarily complicated machine. There the question was how to insure that the various colleges in which engineering was taught might be induced to coöperate with each other and form one homogeneous system.

I will mention one or two things that stand out in my mind. One was, in London there was a very strong disposition in several of the colleges there to encourage more and more the invitation of specialists from the industries to come, lecture, and take part in the teaching of the various colleges—not men necessarily engaged in teaching before, but men from lifelong engineering practice, and very great benefit was found to grow from that somewhat new development.

Then, in Manchester, we are faced with a situation something like that which prevails here. We have a great technical college there alongside, but not actually a part of the university. As a matter of fact, in Manchester, the college of technical training is practically new to many here, being the property of and administered by the city, but it works as a very close corporation with the university, and I think there, as with the Imperial College in London, where similar conditions prevail to the same extent, the technical colleges gain from close contact with the universities, for with us the university, as contrasted with the technical college, stands for liberal education, and the mere fact that the technical college is immediately connected with the university guarantees that the training shall not be of a purely vocational type, but will stand for the more liberal provisions necessarily made by any university.

Extremely important in the British system is this, that the function of conferring degrees is vested in the university alone. The engineering college, although it may have been founded quite independently of the university, if it wishes to obtain for its students degrees, gains everything by coming in close connection with the university through which degrees can be conferred, and there is the necessity of widening its curriculum and of strengthening the liberal side of the education given.

I have always thought myself, and this an allusion to what Dr. Walker has just said, to some extent, there was one aspect of education left out of account by any scientific and technical training, and that is the more detailed study of the history of scientific thought. You may call it philosophy or what you will; but if it forms an integral part of technical education, you will find something of human interest and even of human sympathy which goes to build up the history of the development of scientific thought.

Now, if I had known I was coming here to address a meeting of teachers of an engineering college, before starting I should have taken some pains to ascertain in England what was contemplated and being done. As a matter of fact, in the north of England the engineers were proposing to report on the whole question of engineering necessities as I left, and issued a draft of important subjects. I have not brought that with me and could not get important information on what they were reporting. But I think it will be found that there is in the north of England at the present time a tendency developing to expect that the student—the university student in particular—shall get his practical experience in work to some extent before he comes to the university. Of course, there is the lifelong discussion about sandwiching practical experience with university teaching going on there as elsewhere; but I think the tendency is now rather to hope that the engineering student will be expected to get some familiarity with the conditions of practical work before he enters the university course and not develop any elaborate system of sandwiching technical experience with college training, although the conditions are good to get practical experience.

I think it will have a tendency to develop some differentiation of courses leading to different grades of educational experience so those qualifying to become managers, those qualifying to become directors, and those qualifying to obtain advanced positions with the works will be encouraged to pursue the differentiated course. I do not speak with authority on this matter, however.

But there is one fact worth noting, that the British universities, partly led by a desire to encourage the interchange of students between Great Britain and America—and that, as you know, is one of the objects of our Mission—but also inspired by the desire to improve their own schools of advanced study and research, the border universities have begun to institute something closely similar to your doctorate of philosophy. We had formerly no doctorates except such as was given for a very high standard of work, and not necessarily involving any systematic course with the university that gave the degree. In Oxford, Manchester and other universities, this new doctorate of philosophy has been established, giving to all faculties which will be given under a systematic course of advanced study and research lasting some years. We think that will be a great help to us in strengthening our own university schools of advanced study, and also be a convenience to those American students that come to Great

Britain for university work and the work leading to a doctorate.

One feature of the work will be that students can pass one year in the period of the doctorate at another university recognized by the university at which he has studied, and further the only condition in those directorate courses will be that the student is a graduate of a part of the university and it shall appear that he has qualified to pursue the course which he intends to enter.

In our journey through the states I was only one of the commission to do so who was able to visit the University of Cincinnati, which interested me because like Manchester it is a civic university, and also because I was able to hear something there about a very elaborate system of coöperative work which prevails in the engineering department. I won't say anything in criticism of that as you know what it consists of, but it did seem to me surprising that so short a period as a fortnight should be chosen as the period during which the student alternates from practical work to practical work in the engineering shops of the university, and yet it seemed an extraordinarily satisfactory system and worked extremely well. But I noticed one thing in traveling among the universities, and conspicuously there, that the laboratories are so frequently encouraged to receive gifts of machinery, given with the best of intentions, but which, being gifts, have been allowed to remain so long in the laboratories as to become obsolete, but in Cincinnati they escaped that difficulty. And in some other laboratories the heavy machinery used seemed to be deposited on loan from machinery works, and therefore again seemed condemned to remain in perpetuity in the laboratory after it became obsolete. I think our own engineering laboratories have a great deal to learn from this country; I think they will see in many cases a tendency for machinery to remain too long in the laboratory where first used. I think we fully realize in Great Britain that it is the duty of our university in particular, in conducting engineering education, to have special regard for the claims of those intending to become captains of industry, and a very great effort made to discriminate between training in the technical school with the more liberal and wider training given in the university, only we have far too few institutions where that training is being provided. I think I am right in saying there are seven times as many students of technology in your schools as in ours, and that it is a very large disproportion; it means we are not training a sufficient number of those who are destined to become leaders in the engineering world, and are devoting perhaps too much attention to merely the rank and file of the profession on whom some of the university training would be to some extent wasted.

Now, a very interesting feature growing up in the north of England at the present time is the effort to encourage the universities to get into closer and more intimate touch with the industries, and a significant feature of that is that a considerable number of firms are beginning to find it worth their while to institute scholarships at universities. It is true of chemical tests that young men may be trained in methods of higher research work. That will be encouraged by us. I fancy it is exerted here more than with us, and it has been sugested in England that it would be very welcome at our universities. But I think I particularly wanted to call attention—and the reason was, at least one of the reasons, why we came here to-day—was to call attention to the fact that in my mind under present circumstances of the world's history we have got to remind ourselves more than ever of the more national and international responsibilities which attach to the profession of engineering and mining engineering—the professional engineer and the mining engineer. He travels over the whole world, obtains positions of great responsibility which often lead him away from the profession to other responsibilities, more than falls to the lot of other professional students. I think Dr. Walker alluded to that, that he is a man who will have to gain a very varied knowledge and experience of the world in all its aspects, and have to know how to deal with men. He has the advantage of providing for the alternation of his experience in the works with experience in the laboratory, and it does bring the student, at an early stage of his career, into close contact with the workers themselves.

We are face to face in the immediate future with very important and very difficult labor problems which make one think it will be disastrous if we send out in the engineering and mining profession men who have had too much academic experience and too little experience in practical work. It is now more than ever necessary to them to be in close, intimate, sympathetic touch with the men working under them, and it is desirable to have such subjects as industrial history and social economics made a part of all engineering courses. I do not know how far that is the case in the states at present, but I know that with us that ought to be one of the humanistics necessarily introduced into engineering education to a far greater extent than as at the present time.

There is the recent development in England in favor of introducing in some engineering courses more definite and detailed instruction in business administration. I have noticed where that has been mentioned in Great Britain it has been regarded with some suspicion by the workers themselves, and if they are to have increased influence in educational problems —at any rate, in Great Britain— they will look with suspicion on anything that bears the name of industrial or business administration which seems to them to mean the vocational training of the worker in order to make him a better mechanic.

There is a remarkable movement taking place in Great Britain at present in which the more intelligent, the more intellectual of the workers are claiming more and more for themselves and their associates non-vocational training of the same sort which has been the privilege of the employees in industry to receive. Forty years ago, there was a new impulse to vocational training in England, very conspicuous at the time, but now there is a movement emanating from the workers themselves asking the universities to give them more non-vocational training of a sort which will help them to become better, happier, wiser citizens as well as more effective workers in their respective industries. That request coming at the present time is very largely responded to by the universities and I hope will lead to closer and more sympathetic relationship between the universities and the workers, because there has been a somewhat growing suspicion on the part of the workers, not only towards the employers and capital as a whole, but towards the university as standing somewhat away from them and providing for a different class than those now anxious to enter into the university.

In Great Britain, new impetus is given to this by the new educational act, which provides there shall be continuous education from five to eighteen, and that means that in those workers who left the primary school at fourteen to go straight into industry, they would have to attend continuation schools for eight hours a week during forty weeks in the year, being paid their wage, that being regarded as a part of their business career. In the continuation schools it would be too much expense of a non-vocational character, and if that is properly administered, and if the university took a proper share in it, they will be more than ever able through schools of engineering to get into sympathetic touch with the situation. I apologize for the somewhat rambling character of my talk. I thought of speaking about something else, and, between the two, have given you a very unsatisfactory and fragmentary discourse.

ADDRESS.

BY DR. JOHN JOLY,

Professor of Moral Philosophy, University of Glasgow.

Ladies and Gentlemen: It might appear I knew all about this subject because I am a civil engineer by profession, but when I tell you that the total amount of money earned by me as an engineer has been sixteen and eight pence, you will decide that I have not had much practical experience; in fact, I appear as a teacher of applied civil engineering, and also of most of the subjects that enter into the curriculum of engineering study.

Now, I am not able to speak on the subject of mechanical engineering. The branch of the subject upon which I hope to address a few remarks to you is what we call civil engineering in Great Britain; it is concerned with the construction of railways, of harbors, of roads—civic engineering, generally, and so on and so on. It may be interesting to you to know what the curriculum is in such British schools of civil engineering as are distinct from those where mechanical engineering is taught. For instance, in my own university, the University of Dublin, the student learns practically no mechanical engineering. His whole time for three years is spent in the study of civil engineering, and he has a busy time of it, and except we added another two years or another one it would be to add to the present burden on any of the subjects desirable for an engineer to study. The time of the student is absolutely occupied; he is lectured to about five hours a day on the average, and, in addition, has his own work to make up in the evening; so he hardly gets time enough to keep himself in health by the necessary amount of athletics which we encourage.

In the first year of his work he enters upon the subject of mathematics as a primary and most important subject, and he is carried as far as the differential and integral calculus, so far as that branch of mathematics is required for the solution of problems in calculating the strength of girders and other mechanisms. He is also taught dynamics, kinetics, and so forth, and all the branches of the subject; he is also taught chemistry and physics—all this in his first year. He is taught mineralogy, he is taught leveling, and he is taught building construction; meaning by that simply the use of bricks, mortar and ordinary masonry.

In the second year his mathematical education is carried a little further, or, rather, I should say he is practiced—he applies this mathematics more than he did the first year; the first year is more theory, and the second year more the application of it. He carries his engineering studies further. He deals with hydraulics, with the subject of road construction, civil engineering and railway engineering; he also studies physical geology.

In the third year—his third and last year—he goes much further into the problems of constructional engineering, such as archway construction, retaining walls, and any other engineering constructional work which enters into the work of the civil engineer. He studies historical geology, petrology, the study of rocks and mining; he also studies electrical engineering especially, and the steam-engine.

You will imagine now—those of you who know what I am talking about—that the student has a good deal to do in those three years; he is about as hard worked as he could be.

Now, about the humanities that Dr. Walker was talking about. Well, we have the provision in Trinity College that the student cannot obtain his degree in civil engineering except he is, first of all, a B.A.—a bachelor of arts. He can if he is able to run the two concurrently. The bachelor of arts is a four years' course, and it very often happens that the student having matriculated in the arts takes this first year of the arts by himself, and on the second year he joins the school of engineering, so that his course in engineering and course in arts ends simultaneously. But, you see, he is compelled to read somewhat into classical knowledge, which is restricted to Latin; that is the only branch compulsory upon him. He may take Greek if he likes, in addition to the Latin, and also the modern languages, English literature, logic, and so on—a few other subjects; but he cannot become a civil engineer, he cannot boast of being a B.A.A. of the University of Dublin except he has first taken his B.A. He can take a diploma or license—we will give him that—a licentiate of the Trinity College of Dublin is a man who has certainly less general culture than the man who can boast of the degree of civil engineer.

Now, what I have said about the University of Dublin applies to other universities in Ireland, to the best of my belief, but changes are so frequent I cannot talk with certainty, but it applies to the National University and to the University of Belfast.

I think it is likely that an American student coming over to us, as I hope they will, would find some changes in the way engineering is taught in our Irish universities; and I may observe here that I believe the University of Edinburgh is much the same in its curriculum—I believe the students would find some changes in taking up the engineering course of these universities. They of course differ very much from the schools of engineering which generally exist in your American universities, so far as I can gather. The student, with us, is taught practically no mechanical engineering. The design of the girder—I won't say ''design,'' but the construction of the girder—is left to the mechanical engineer; the civil engineer can design it if he pleases and submit his designs to the mechanical engineer to have them carried out or modified. His knowledge is not supposed to extend to the technique of girder construction. He understands how to test materials for strength; he gets a course in the strength of materials, and is shown how to use the testing engine and make the various tests required. He is taught how to use the lathe, but all the thousand and one things that the mechanical engineer has in addition to learn he does not learn. He is not taught them nor do I think it desirable.

Now there are one or two points I would like to dwell upon for you who are interested in the subject I am talking about, and they are points which after very long experience in teaching, I think, are too much neglected. In the first place, mathematics is, in my opinion, not carried far enough in the engineering schools, so far as I know of it. The difference between the student who can rely upon his mathematics and who knows how to state his problem in proper form so as to apply mathematics to it, and the student helplessly going about to get somebody else's brain to help him out of his difficulties, is enormous. To my mind, that constitutes the difference between the good engineer and, speaking generally, the second rate engineer; I do not say it is always the case, but in general that is the case.

Some men have not got mathematical ability—I quite admit that. There seems to be in some minds something antagonistic to mathematics, but most men can by careful teaching be brought to the ability of applying mathematics to engineering studies, because the mathematics is not really very advanced, and it is only a question of having patience and taking pains in making the student a master of the amount he should know.

There is another subject I think is too much neglected and that is the subject of handwriting—calligraphy. Over and over again the student who is supposed to have finished his engineering course really cannot write as he should; he spoils every engineering drawing with which he is concerned or for which he is allowed to do the writing. Now, I do not say the writing should be quite as ornate as those letters which reached me from your association, and which contained the most beautiful calligraphy in the best India ink, it cannot be so elaborate as that, but it should be clean and neat and not sprawling all over the paper. Students should be taught, above all, to write well.

Now the subject I have been teaching the last fifteen or twenty years is geology, and I would like to say a word as to the absolute necessity of the civil engineer's learning that subject. I quite admit that mechanical engineers may not require it, probably they won't; the man who spends his life in the workshop may not need to know anything about rocks, minerals, or stratigraphic geology, but the engineer who wanders over the world has great chances of finding new deposits and to rely on his own knowledge for the value of building materials, and to turn out that man without a good knowledge of minerals and rocks is simply an act of wickedness; you deprive him of the chances which fall to him in the pursuit of his profession.

I remember some extraordinary examples of that in the course of my life. I have known a student to send from India to London a large sack filled with ordinary yellow mica, known as biotite, which looks something like gold, looks like little spangles; and he filled a bag with these spangles and posted it in a sack to London to have it examined, which was a silly thing to do. Another case I heard on good authority of an engineer who constructed a railway line some place in South America, allowing a valuable amount of cinnabar to spoil. In fact, he constructed the railway of cinnabar, which is the chief ore of mercury and exceedingly valuable. The cinnabar remained there with the trains running over it until found by accident by a mining expert, who, looking out the carriage window, noted the brilliant color with something unusual about it, and he went back to examine it and found out what it was. That is an example of what bad engineering can bring about. Another case of a different character arose in the neighborhood of Dublin some time ago. There was an extensive and valuable erratic of granite, the most beautiful boulder in Ireland. This block of granite, about half the size of this room, had been carried a distance of six miles from the mountain and was resting on the Cambrian Rocks of Wicklow. They were constructing a dam to increase the water supply of Dublin, and the engineer in charge broke up this erratic for the sake of paltry tons of granite that was in it, and carted the whole think away, destroying a natural curiosity of the greatest value and interest; there is not a trace of it now, and I think the engineer ought to have had a sufficient knowledge of engineering to know what he was dealing with and not be guilty of an act of destruction of that kind.

Well, now, gentlemen, I do not know that I have anything to add to what I have said. I am trying to keep as practical as possible, because you have had remarks of a more or less theoretical character, but I am in substantial agreement with practically everything that Mr. Walker and Mr. Miers have said.

KEEPING THE TEACHING FORCE ALIVE.

BY CHARLES ALLEN WRIGHT,
Professor of Electrical Engineering, The Ohio State University.

During the discussion of all phases of engineering education which is to be expected now that Dr. C. R. Mann's "A Study of Engineering Education" has been published, is the proper time to make a suggestion in regard to one of the most important problems which is presented to engineering schools, that of keeping the teaching force in touch with commercial engineering development.

As was mentioned in this report, the tendency in most of our engineering schools has been to encourage research, principally in the field of pure science, and the importance of educational research which has been neglected was emphasized. It is probably even more important that the instructional staffs be developed along commercial engineering lines. By far the greater number of engineering students should follow the course of instruction in which they are properly most interested, that of becoming acquainted first with commercial engineering problems and methods, and then if they have a natural adaptability for scientific research, undertaking work of this nature. In order to instruct students in this way it is essential that the instructors have a reasonable amount of first hand knowledge of commercial engineering practice, and it is much less important that they have any of the knowledge or ability developed by research.

It is not the purpose of this article to consider the salaries of the instructors in our engineering schools. Little need be said about them. All who discuss the matter agree that salaries have not kept pace with the cost of living or with the salaries paid men of like ability in commercial work, and the consequence is that many of the best instructors are attracted to commercial pursuits,—or we might better say forced to them, and many more of those who, actuated by more or less altruistic ideals, do not give up educational work, are prevented by never ceasing financial worry from reaching their greatest development. For the older teachers who have been able to establish national or local reputations as experts in their professions and are thereby able to obtain employment as consulting engineers, the problem of keeping alive to developments in their field and the points of view and methods of work of practicing engineers is not difficult. Not only are they able to keep their minds alert and well informed, but their consulting fees are generally sufficient to protect them from financial worry which would make the struggle to exist rather than the struggle to create their most urgent problem. This is not the case with younger teachers and the effect of these conditions upon them is reflected in the quality of their teaching. In most engineering schools the bulk of students are taught to do commercial engineering work by men who have never done any of it.

It would not be just to underrate the chances offered instructors to develop, not by the colleges, but by manufacturing and public utility companies. Many of these, such as the General Electric Co., the Western Electric Co. and the Westinghouse Electric & Manufacturing Co., offer instructors generous inducements to spend the summer months or other available time at work in their shops and offices. The greatest objection to such experience is that men do not retain their connection with these companies for a sufficient length of time to become familiar with the routine followed in the various departments so that they may be made responsible for important work. In order that they may be of value to the companies who employ them, to themselves and to their students, it is essential that they take the responsibility for work of at least moderate importance. Again, many instructors on salaries, in too many cases less than those necessary to live decently, cannot afford the expense necessary to avail themselves of the opportunities offered.

A plan which has been discussed with a number of teachers and executives of engineering organizations and which offers possibilities of improvement in these conditions is one by which engineering schools will exchange employees with manufacturing and public utility companies and other industrial organizations for periods of six months or a year, each employee remaining on the pay roll of the engineering school or industrial organization by which he has been employed, and that engineering school or industrial organization paying all of his expenses in making the change from one position to the other. Organizations such as the Western Electric Co., the General Electric Co. and the Bureau of Standards, would each have ten, twenty-five, fifty or more men as their needs demanded available to exchange for a like number of men from engineering schools. Such men of any one industrial organization would be distributed to different engineering schools each year, or retained in the shops or offices of the organization in order to obtain necessary experience.

If, for example, an electrical engineering department in some school of engineering employed two men who had specialized in electrical power machinery, one who had specialized in central station engineering, one who had specialized in telephone engineering and one who had specialized in electric railways, the telephone man during one period of six months or a year, would be exchanged for a telephone engineer from some industrial organization, as the Western Electric Co. The Western Electric man would have a fresh knowledge of telephone apparatus and practice, and after he has been exchanged one or more times, some teaching ability. Even the first time he was exchanged, his fresh and practical knowledge of telephone engineering would probably compensate for his lack of teaching experience, and he would at least be more satisfactory than the teaching assistants now employed in many engineering schools. The next year one of the power men would be exchanged for an employee of a company such as the General Electric Co., then the central station man would be exchanged for an employee of a large central station, and so on. The engineering school men would remain long enough, six months or a year as suggested above, with the industrial organization to become familiar with the routine of the organization and to become responsible for more or less important work. These men would thus be of value to the industrial organizations and, because of the character of their work and the degree to which they would absorb the spirit of the industrial organization, their value as teachers would be greatly enhanced.

At the end of a college session during which a man from the Western Electric Co. would take the place of the telephone man, it is probable that most of the students graduating in electrical engineering would be persuaded to accept employment with the Western Electric Co., but the next year when a man from some other industrial organization would be detailed to the same electrical engineering department, that organization would have the preference, and the Western Electric man, if he were able to make a good impression on students, would be able to gain the preference in some other electrical engineering department for the Western Electric Co. Thus each industrial organization would each year have a number of spheres of influence, the location of which would change from year to year. An advantage of this condition would be that the present tendency in many electrical and other engineering departments of engineering schools to send all of the men year after year to the same industrial company would be decreased, and its alumni would be more widely distributed.

Each year there are many interruptions to regular work because of the visits of representatives of the various industrial companies in their scramble for men. These interruptions would be decreased because, although the preference of the students would determine where many of them would go, there would probably be a tendency for industrial organizations to concede the men in any engineering school department to the company represented in that department in that year.

It would be possible for engineering schools to obtain better instructors if such an exchange plan were established, because these men would not feel as they frequently do now, that they are cutting themselves off altogether from commercial work when they engage in educational work.

The objection might be raised by engineering schools or industrial organizations that such an exchange will mean that the employees of both the industrial organization and the engineering schools who are thus exchanged, will receive offers of increases in salary which will induce them to leave the organizations for which they are working. This is to be expected to some extent as the value of the men increases, but few organizations of the importance of those to which this discussion applies will object to taking such a chance in order to greatly increase the value of their employees and their work. The salaries may be expected also to soon reach a level beyond which there will be no marked increase which might be charged to the exchange employee system rather than to the normal increase in the value of the employees.

It would not greatly increase the salary and other expense of a large industrial company to have ten or more men who would spend every other year in colleges and it would be worth much to them in the improvement in the training of the men they obtain from the colleges. It would entail very little extra expense to the colleges.

The greatest objection to the plan probably lies in the difficulties presented to the men who will be exchanged, but both college men and employees of industrial companies will realize that these exchanges will be broadening and will make possible much development of ability, and it is not to be expected that they will hesitate when their value will be increased and their advancement promoted by such exchanges.

EDITORIAL.

Interchange of Students.—The one subject which was discussed more than any other by the British Educational Mission while it was in the United States was the interchange of students, or more specifically the sending of American students to British institutions during the reconstruction period. This matter was not discussed to any great extent with specific reference to engineering students but it is undoubtedly a live topic since we are appreciating more than ever the value of broad training in conection with engineering education. It would seem that some such plan as the following would tend to develop an excellent all-around man especially well acquainted with the general problems of engineering.

Let a young man complete his four years of engineering instruction in this country, spending a portion of that time in the industries thus becoming to a certain extent familiar with the applications of engineering principles to industries. Then devoting one or two years to work in one or more of the larger industrial concerns, then going to one of the English universities for further study in applied science, at the same time devoting a portion of his time to actual work in British industries.

This matter is becoming pressing because England has developed its industries to a much greater extent than America. In this country we still have enormous natural resources awaiting development and the work which is required of the engineer for this is quite different from that demanded of the engineer in an old-established country like England. On the other hand, this country, of course, tends more towards permanent industries, thus becoming more like England and it is this work which the next generation will handle. It is, therefore, important that engineering students should, if possible, have an opportunity of studying from one to three years in British institutions and becoming familiar with English industrial plants. A man so trained would undoubtedly become a leader in the development of American industries.

COLLEGE NOTES.

Lafayette College.—A memorial scholarship, growing out of the World War, has been established in the Department of Mechanical Engineering at Lafayette College. The scholarship is to be known as the "William Ward Frick Memorial Scholarship," in memory of the late Captain William Ward Frick, of the class of 1914, who was killed in France. The donor is William E. Frick, of Sewickley, Pa., Captain Frick's father, and will yield an income of $250 a year.

CONFERENCE ON TECHNICAL NOMENCLATURE IN NEW YORK, DECEMBER 2.

An important meeting of the Committee on Technical Nomenclature of the Society for the Promotion of Engineering Education and representatives from other national engineering societies was held in New York, December 2. The following were present: Professor John T. Faig, Chairman of Committee on Nomenclature, Society for the Promotion of Engineering Education; Dr. Charles Warren Hunt, Member, Committee on Nomenclature, S. P. E. E. (secretary, American Society of Civil Engineers); Mr. L. G. French, Chairman of Committee on Nomenclature, American Society of Mechanical Engineers (editor, A. S. M. E.); Mr. George R. Metcalf, editor, American Institute of Electrical Engineers; Mr. J. M. Lloyd, Publication Department, Society of Automotive Engineers; Mr. D. E. Jones, managing editor, American Institute of Mining Engineers; Mr. Sanford A. Moss, Member Committee on Nomenclature, S. P. E. E. and A. S. M. E.

A preliminary discussion indicated that all present were agreed that the formation of a general committee for the standardization of nomenclature, and particularly the standardization of symbols for mathematical and scientific work, was desired. A formal organization was made by the election of Professor J. T. Faig as chairman and Dr. Sanford A. Moss as temporary secretary.

A general discussion showed unanimous agreement on the proposition that the standardization of technical nomenclature is highly desirable and that this was an opportune time to take up the subject. There was a discussion of the status of those present and it was agreed that the Conference should consist of the original S. P. E. E. committee with the addition of delegates appointed by the other national societies. It was agreed that the Conference should be enlarged by the addition of delegates from all other national societies which might be interested. A tentative list of societies to be represented was made up as follows, subject to additions by the chairman:

Society for the Promotion of Engineering Education.
American Society of Mechanical Engineers.
American Institute of Electrical Engineers.
American Institute of Mining Engineers.
Society of Automotive Engineers.
American Society of Refrigerating Engineers.
Society of Heating and Ventilating Engineers.
American Physical Society.
Western Society of Engineers.
Bureau of Standards.
American Engineering Standards Committee.
American Society for Testing Materials.
American Chemical Society.
American Society of Chemical Engineers.
Society Naval Architects and Marine Engineers.
American Society of Civil Engineers.

The symbols adopted by the International Electrotechnical Commission were exhibited. It was pointed out that these symbols are in universal use throughout the world by electrical engineers. It was agreed that this list should be adhered to by the present committee. The list of symbols for Mechanics and Hydraulics approved by the S. P. E. E. on June 28, 1918, was also discussed. It was agreed that this list be accepted as the starting point for the work of the Conference. This list may be changed later, if necessary, to receive general acceptance by all or nearly all of the societies. It was agreed that the work of the committee should cover symbols for heat, including steam and gases, mechanics, including statics, dynamics, kinematics, strength of materials and hydraulics, geometrical optics, physical chemistry and related branches. In each case the purely scientific, as well as the engineering side of the subject, should be covered.

It was agreed that a letter should be sent to each of the societies in the above list, including additions to be made by the chairman, inviting each society to participate in the work of the Conference and officially to appoint a delegate to represent it as soon as convenient. Each society is to be asked to send in a list or lists of symbols in common use in its own branch, prepared, either by a committee appointed expressly for that purpose, or by the delegate of the society to the Conference. Other interested persons are also to be asked to send lists of symbols. All of the lists are to be sent to the chairman of the Conference before February 1, in order that they may be compiled and charted for presentation at a meeting of the Conference which is to be called as soon thereafter as is feasible.

S. A. Moss,
Temporary Secretary.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, ***Editor.***

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., FEBRUARY, 1919 NO. 6

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THE TRAINING REQUIRED FOR ENGINEERS.

BY MAJOR GENERAL WILLIAM M. BLACK,

Chief of Engineers, U. S. Army.

Mr. President and Gentlemen: I cannot say I have a paper, but I have something I want to say to you. The subject that is put down is the training required for army engineers. I think, perhaps, I had better make it a little more specific. We have two distinct classes of engineers employed on war work, one is the combatant class and the other the non-combatant class. That perhaps I can illustrate by telling you of two distinct kinds of organization that we have in the Army itself—of engineers. We have our sapper troops and the troops who are liable to be employed at the front in the theater of operations and under fire, and who must work under orders of the general commanding the particular section, and who frequently do have to take a place directly in the line of battle. Those are combatant engineers.

Then we have another class of troops who, in France, are organized under service of supply,—"S.O.S." as it is termed. Those men are not expected to be under fire. They are just as essential as the first class, because on the S.O.S.—on the ability of the S.O.S. to supply the front is determined the possibility of movement,—the possibility of action. All the immense mass of supplies constantly required must be handled by the S.O.S., so that is just as important a factor, just as essential a factor as the actual fighting troops at the front; but the engineers of that particular class, those in the service of transportation and the men in the service of production are non-combatant troops.

And it is illustrated in the way the regiments are made up. In combatant engineer troops, the officers who are all engineers by profession, and the non-commissioned officers are selected from the military point of view,—the ability to control men in action, as shown by their ability after they get into service, if there has not been a chance to test them before as to their particular military qualities when candidates for commissions and for the non-commissioned officer grades for the combatant troops.

For the non-combatant troops the non-commissioned officers are selected simply from a knowledge of the work they have done in civil life. For example, when we take a railway operating regiment we select for the officers the officials who held positions in railways in civil life,—superintendents, train dispatchers, and so forth, and we give them a rank somewhat in accordance with their relative positions in those civil offices. The same in the shop regiments,—work in the roundhouse or in the shops for the repair of locomotives or train material, there again the commissioned and non-commissioned officers, although given military titles, these are in accordance with the work they have done in civil life of the same character as that which they have to do in military life. So there is that marked distinction between the combatant engineer in the war and the non-combatant; but what I am talking about now is more particularly the training required for the combatant engineers.

In order that you might appreciate the kind of training and why we think this certain kind of training is necessary, it might be well to review a little the duties of the combatant engineer. The engineering profession of our country was most patriotic in its response to the call of the country to arms,—almost to a man they offered their services; but many came to me and said, "I am an expert in concrete construction and I offer my services as a constructor of concrete." Another man would say, "I am an expert in water supply," and another, "an electrical expert," and "I offer my services in that capacity to the Government." The answer I was compelled to make to all of those gentlemen was that the Government does not want a one-sided expert; the Government for its combatant troops, wants a man who is able and ready to do anything in the wide world he is called upon to do, because that is the only kind of a man we can use at the front. Not that we undervalue expert knowledge at all, and do not think it quite necessary, but that there is very little room for specialists. It is perfectly manifest, if you think of it, that you cannot have on your staff right at the front a large number of individuals who sit around and wait, say, until an electrical problem comes up, and then one jumps up and does it, or until a water supply problem comes up—you cannot do that. But you have to have a class of men sufficiently all-around engineers to be able to do all ordinary tasks of that kind that fall to the Army; and, of course, at the front, ordinary and not extraordinary tasks are those presented for hurried execution. I would say that the need for specialists at the front is exceedingly limited.

A man must be, first of all, an all-around engineer, capable of tackling anything, understanding all the principles, all the applied branches of engineering, although not necessarily a great specialist or expert in any one. Of course, if he is an expert in any one, in addition to that, so much the better—by all means; but best of all is to have the all-around training.

Have you thought what these combatant engineers have to do and have done at the front? Suppose we begin right out at the front. The men have taken up a position, and the first thing these engineers have to do is to go along the very front line and see where the troops have been placed and get that line organized then for defense,—move these men a little further forward and those a little further back, take the hastily dug trenches and form them into an organized line of trenches, and then put outside of that the obstacles, then they make connecting lines of trenches, then other positions to the rear, and so on. That is purely military work and in this trench warfare a knowledge of geology is of great value. Also you have to have drainage; you have to have your water supply; you have to have sanitary engineering right in that front line work.

An attack is going to be made. Up come your engineers to clear away obstacles, and the placing them or the clearing them away does not constitute a good life insurance risk, gentlemen. There comes in there not only personal bravery, but every man has to have expert knowledge of explosives,—how to make the smallest amount of explosives placed at a certain point produce the effect required, because if you do not get that effect it means the sacrifice of human life. That is their work.

The rush is made, the army goes forward immediately, the engineer must see that the roads which have been torn up by shell fire and mines are made practicable for transportation, for, of course, transportation must keep up with the army all the time, there must be movement of men, of materials and of supplies all the time. He must see that his light railway system is carried forward; that any of the enemy's railway which has been captured is put in good condition and position and carried forward; railway operation and railway maintenance must be carried out, and they are good problems. Taking these last two advances over there, frequently the only road material available was the material that the boches had made in the towns by knocking down the houses. I wish I could tell you in detail much about the roads and their traffic regulations. Some roads were two-way roads and others one-way. In certain cases new roads had to be constructed miles in length, and in repairing these roads and building them the material was brought in motor trucks,—carried to a point where needed. The trucks sometimes had to go in a long detour and then back to take up the material for construction again. A small part of a main railway line is captured, and that the boches have very carefully destroyed by putting a charge of explosive under each rail joint and blowing the whole business out, so if the rails were not carried away bodily, only something like forty per cent. of the whole track material was left, the ties having been burned or carried away entirely. So you have railway construction and maintenance, and then in the theater of operations these same engineers at the front must operate the trains.

It may be in this warfare that we find that mining operations are necessary, and there comes the need of the special knowledge. This work is attended by all the risks of mining you would have in ordinary civil pursuits plus the risk of some fellow trying to blow you up while at it. This calls for the necessity of working at night, so that always in the rear front line it was necessary to carry on a lighting plant and establishing lighting systems. Shops have to be run, and means of carrying power lines from a generating plant far enough from the rear to be fairly well protected from shell fire must be had. Through all this there is necessity for constructions which have to be proof against heavy explosive shells, calling for resourcefulness and knowledge in construction work, and all to be done very quickly. Immediately in the rear of the front lines whole villages had to be made bomb proof and had to be concealed from the enemy. They had to be supplied with sewers, with water and with lights.

So right in that front line work there is almost every possible class of engineering called for and this has to be done by the combatant engineers.

Farther to the rear there are whole villages that have to be constructed. I had a note from one engineer who said he was making a hospital for 25,000 beds, which entailed the building of over 1,000 separate houses and some 50 miles of pipe for sewage, water, and the different electric transmission lines. In the great depots for supplies long lines of warehouses have been constructed, each one supplied with a railway track and with a roadway,—the railway track on one side and the road on the other, all lighted electrically, all supplied with water and all supplied with every facility for use. In connection with those, there were great railway yards for the classification of the trains.

Then you come to the ports, and the ports themselves had to be constructed. In many cases dredging had to be done and piers had to be dug; in many cases a thousand or a million square feet of storage space and miles of trackage had to be provided. That S.O.S. service was in part performed by non-combatants, but in part by combatants because the possibility of changes incident to all plans has to be provided for in the army also. It is better to have an excess of combatant engineers so there may be greater flexibility in the organization.

I have not mentioned the forestry troops, and I can tell you rather an interesting thing that occurred in connection with some of these troops over there who did not have time to get much military training on this side. In answering a hurry call sufficient training was given only to get the men organized to drill them enough to get on and off a train or boat in an orderly manner, and for instruction to the officers in how to make out the necessary papers to supply their men. The troops were supposed to go back into the woods and do exactly what they had been doing on this side, and non-commissioned officers were over them in the same relations as foremen, etc., as on this side. But in sending those troops over, one battalion was in a transport that was torpedoed off the north of Ireland, and they lost all their clothing, tools and equipment. When they arrived in France they had to wait to be equipped. They then went to a training camp at Angers. This training camp was a training camp for the combatant engineer troops and there the men were given a very severe course of training for combatant work. I wish you gentlemen could have seen that kind of training. I never saw anything so well calculated to make a man all that he possibly could be in efficiency as that training which was given to our men,—in coördination of mind and muscle and the development of the body to its highest degree of efficiency the work was wonderful. I never saw such an exhibition of human endeavor and "pep" as was found at Camp Lee, for example, under Colonel Peterson, who will shortly be dean of our new school at Camp Humphreys. That kind of military training you would not have supposed to be strictly necessary for this non-combatant unit, but these men had been sent to Angers, and the commanding officer gave them the regular training of the camp for the period of their stay. The photographs taken of them drawn up in formation at the time they arrived there, and again just before they left, after their equipment had been received, show an enormous gain in physical form. But these men then went out into the woods, and what was the result? That battalion immediately made a greater output of timber than any other, simply because it had had this training. Individual training and training in team work gave this result.

So we have, then, those two classes of work for our engineers, and you can see from the duties that I have outlined that for war work the officers must have a very broad foundational training as engineers. They cannot be allowed to specialize in anything unless they have this basis on which the specialty can be founded, they must know the general principles of engineering through all branches.

We, in our corps, have been fortunate in our preparation for war, and I think that the country has been fortunate too, not so much perhaps through forethought as through accident, in having allotted to the custody of the Corps of Engineers a large proportion of civil work undertaken by the government in the time of peace. Had it not been for this civil work, our army men could not have had the training that was necessary in the war. There is very little work in peace time for the combatant engineer in the army itself—in the army proper, and if we were confined to that class of work, war time would often find us in the position of the man who had studied medicine but never practised it, or the man who had studied law and never tried a case before the court; we would have been perfectly worthless for the work we had to do. You remember one of George Eliot's novels, in which she speaks of a gentleman who was collecting material for a very erudite work. He made notes and notes until he found one day to his surprise that he was getting on in years, and if he was ever to write the book which he had made his life's purpose he would have to begin. Then he tried to use his notes and found that he had been collecting notes so long that he could not do anything else. And that is true of a course of engineering without practice. You have to practice or your study is wasted.

So it is very fortunate that Congress has intrusted to the Corps of Engineers of the Army the enforcement of the laws for the protection of navigable waters and has charged it with a large amount of civil work in connection with rivers and harbors, and other federal work. Incidentally, when the government has work of that character, the army engineer is well fitted to help the United States, for they don't have to hire him for a large figure and can trust him to devote himself to the nation's interests because he has no other axes to grind.

As an illustration of the variety in the work of the army engineers, I will name some of the lines of work that have fallen to me as a part of my official duties—not as a unique experience but as typical of the kind of work which a military engineer must do.

My first duty in the field after graduation at the Military Academy and service with the Battalion of Engineers started in 1880, and in 1880 and 1881 I was employed as assistant in the construction of locks, and fixed and movable dams on the Great Kanawha and Ohio Rivers.

In 1881 and 1882 as assistant in the Philadelphia District, and had to do with questions of river regulation, control of ice flow and harbor lines.

From September, 1883 to December, 1886, I was instructor at the Military Academy in Practical Military Engineering, and on duty with engineer troops.

From January, 1887, to November, 1891, in the District of Florida I was employed on the improvement of the mouth of St. Johns River involving the construction of jetties, improvement of the channel of St. Johns River by dredging and regulations, improvement of other rivers in Florida, hydrographic surveys for harbors in Florida which necessitated study of tides and tidal action, and in clearing away obstructions in various rivers. Incidentally it became necessary to design and construct a sternwheel boat which should be capable of snagging, pile driving, and hydraulic dredging.

From 1891 to 1895 I was on duty as instructor in civil engineering at the U. S. Engineer School and in command of a company of engineers.

From 1895 to 1897 on duty in the office of the Chief of Engineers in charge of the Personnel and Fortification Branch and during this period had to do with the projects for and design of permanent seacoast works.

From 1897 until May, 1898, as Engineer Commissioner of the District of Columbia, all problems of municipal engineering came before me, among which were the design of a system of street extensions for the District of Columbia, plans for the abolition of railroad grade crossings in the city of Washington, and securing plans for the Connecticut Avenue bridge across the Rock Creek Valley.

Then came the Spanish War with experience in the field as Engineer Officer in the Porto Rico campaign. From 1899 to 1901 I was Engineer Officer on the staff of General Ludlow and later of General Wood in Havana. As such, I had charge of all municipal work in the city of Havana including the cleaning and reconstruction of the streets and design of a sewerage system. Later, to these duties was added the supervision of public works on the island of Cuba. Then came another tour of duty with a Battalion of Engineers and in command of the engineer post-graduate school.

Following that was a tour of duty in Panama inspecting the work then being carried on by the new Canal Company.

Following that came a tour of duty at Portland, Me., involving the design and execution of works of river and harbor improvement, construction of fortification and numerous reinforced concrete bridges.

In 1906 I was again sent to Havana and made Advisor of the Department of Public Works, as such having charge of all classes of public works on the island, including those of sanitation, water supply and lighthouse construction.

Following that duty, in 1909 came a tour of duty in New York City, where all the many problems connected with the river and harbor improvement and the enforcement of the laws for the protection of navigation had to be met. During this tour of duty was carried on the design and construction of the lock and dam of Troy, and the grappling with the many legal problems involved with that procedure, also the problems of raising the Maine from Havana Harbor. In addition, there was extensive work in connection with the land defense of our seacoast cities, and also an opportunity for investigation and report on the problems of sewage disposal in New York. During all of these various tours of duty the enforcement of the laws for the protection of the navigable waters of the United States presented interesting problems of engineering and economic policy.

Now, that was one man's experience extending over a number of years, so you can see if one is called upon to do all that, he must have a broad foundation upon which to build. The supply of army engineers was for many years limited to graduates of the Military Academy at West Point. That school was founded in 1802. The act of March 16, 1802, authorized the organization of a separate Corps of Engineers to be stationed at West Point and to constitute a Military Academy. Consequently, the instruction there was always laid out to get the best results in training men for engineers. The weights given to the various studies and the classification of the cadets on final graduation and for commissions in the Army were based on that fundamental consideration, so that the graduation standing of a man at the Military Academy was quite different from what it would have been under ordinary college rules and marking. The result has shown that the type of men that for many years have been put in the Corps of Engineers has proved suitable for engineering work. While once in a while a man is a misfit and does not do much as an engineer, the proportion is so small that the wisdom of the men who laid down the course has been very well justified indeed.

It has been quite the customary thing for educators to look at West Point as an antiquated school that does not give an engineering education. Does it? Does it profess to? It cannot. Even in the engineering education that it does give, the course is defective. There is time lost; there is a great deal that we graduates don't know and never will know. I had to confess the other day to the president of one of the most successful of all of our engineering colleges that I had a very hazy idea of exactly what the moment of inertia has to do with the transverse strength of a beam, and he said, "I have, too." There is something wrong about that. Don't you see, gentlemen? But with all its defects, West Point has done something. Do you know, gentlemen, that the proportion of the alumni of West Point going into civil life who have filled high stations in civil life in our country is greater than that of any other institution in our country?

Now, why is this? It certainly is not a broad education that West Point gives. Nobody claims that. It certainly is true that cadets do not get a thorough understanding of all that is taught, and I could make other confessions. But West Point must do something or it could not give the results it is giving to the country. And what is that something? I think we could sum it up easily. It is, first of all, that there is inculcated in the young man there the idea of duty; that when a thing is to be done it must be done. It doesn't make any difference whether you want to do it or don't want to do it, it doesn't make any difference whether you think you cannot do it; you have to do it, and that is the first thing that is pushed into them and pushed into them for four years.

And then another thing we have there. The young men being graded according to their ability, the tasks that are given them daily are also graded according to ability to get through that task. It is necessary for the young man to put his whole mind down hard on it. He has no time to think of other things; he has no time to go into side excursions of knowledge, no time for other arrangements; the day's work must be done that day, working as hard as he can to get through. If a man is sick in the hospital God help him, because he loses his place in the class, he loses position in the whole of his military life. I have known a man to lose what is equivalent to five or six years in promotion, lose out on his arm of the service, get into a lower grade, because he had the misfortune to catch the measles and be laid up for a little while. You never can make up at West Point. You must stay ahead; you never can make up back studies. Each day you have to do the work laid down for that day.

Now that induces in this young man the ability to concentrate his thoughts on the work in hand. Then along with that and a part of that is the essential military training of which Dr. Mann spoke. I think there are really very few people in the country, excepting the men who have actually been through it, who know what military training is. Our people have come to think of it as ability to put a gun in certain positions, or the ability to step off together and make a show on parade, and that sort of training. That is not military training. There were thousands of men in the country before the war who could do that sort of thing, who were not soldiers at all. Military training is essentially, as Dr. Mann put it, the acquisition of that self-control that teaches a man where his work is, that makes him do his work as laid down, so that he is only one part in an immense machine which can move, without friction or breaking, towards the end to which it is directed. It is a self-control that must go through the whole life of the man. It cannot be acquired by an hour a day, or an hour a day each week, but it is something a man has to get into him by his whole business of life for years before he gets that true military training, and it is just as essential for civilians, or ought to be, as for soldiers.

Dr. Mann spoke of what the army is. Do you know, if you come to think of it, the army represents the very highest of human endeavor. Where else do we find men working absolutely harmoniously without any lost motion, without any loss of time, toward one single end, with such devotion to the getting of that end that life means nothing to them? To do that requires military training—or training. ''Military'' is a word we don't like—''militarism'' none of us like; but the training that is required for that is the training that will help us everywhere in civil life. You know in our country one of the very greatest things we have to consider in all branches of human endeavor is the saving of time. You take it in the factories abroad or in their transportation system abroad, what they look to is saving of coal; man power means nothing. With us, all our problems must be solved with reference to the saving of men, with the saving of time.

I wish each of you gentlemen could spend two or three days at West Point and see what a wonderful time saver this military system is; how there is no lost motion, how everything that has to be done has to be done in the minimum of time with the minimum of friction; how classes form on the tap of the drum, and the men fall in and answer to the roll call going to the recitation room or going to their studies; and during the entire time allotted for instruction the instructor has no thought of anything excepting the instructions he is giving. There is no difficulty about loss of time in getting there; there is no difficulty about loss of time in getting to the seats, no difficulty of loss of time in trying to hold the attention of the men. It is the most wonderful time saver we have. We are all working for efficiency all the way through. Why is not that efficiency, and if efficiency, why is it not essential for the school—that sort of thing? If we can get that kind of training, the small amount of acquisition of knowledge necessary to pass from the civil to the soldier status is easily attained. That is the kind of military training that I would like immensely to get into all of our schools, and I am sure that if you could ever try it, ever have it, you would deem it absolutely essential.

The War Department was trying recently to make an experiment under impossible conditions. I don't know of any task harder than for a man to go to an ordinary college with a set of undisciplined young men and get that kind of training into them. It requires the highest possible training faculty. Now that training faculty was absolutely essential for the winning of this war and getting the boches killed, because it was needed for training the army to go over there. The result was, the kind of men who ought to have been sent to these colleges could not possibly be spared for that work. I was asked again and again for engineer officers to go to these schools and I had to say that we did not have the men. It was immensely more important to kill boches, and when personally asked by the schools what was necessary for them to do, I said, ''Attend to your instructing, and I will attend to the military end after they are prepared for that by you.''

I am in favor of the kind of military training of which Dr. Mann spoke, and I hope and wish you gentlemen would consider that and see whether it would not be possible in your institutions to do that for the good of the institution, for the good of the men, as a time saver. A little later I am going to tell you some more things tending towards time saving.

So much for West Point. Our young men graduated from the academy and came into the Corps of Engineers. They did not consider themselves engineers, but had a good foundation upon which to build. What we did with them in the first year after graduation was to put them with troops and have them learn how to handle men and get a little more military information. After that they are sent back to their books and then sent to the troops and then another year of school, and then to assist on these various public works. So we looked upon the first ten years after the officer entered the service and received his commission as an engineer officer, as being in a manner non-productive years in which he was learning; the officer did good work, but was always considered in a measure non-productive.

After the ten years' training, after the guided or directed schooling in practice on the works or in school itself, then they were intrusted in the care of works. So the training goes on upward. Now, then, I do not see at all why that same training cannot be applied in civil life. I think it a great mistake to try to make specialists of half-baked engineers. You take a man, for example, who has learned mechanical engineering; it should be his natural aspiration to go clear up to the top of that branch of the profession. Now, unless he is an all-around engineer, how can he ever rise to the top, how can he design entire plants, for when you get into a power plant there is found the application of every kind of engineering; there is no single specialty. He is better off if he has this broad foundation at the bottom. So if possible to do so, it would be infinitely better to take the youngsters at school and put them through your regular course. The course is good; I am going to find some fault with the application pretty soon, but the course is all right. Then let them go out in actual work for a year to get their brains clear as to what they know and don't know, because the boy on graduation is mighty indistinct in his knowledge and knows a good many things that are not so. Then let him come back and specialize, and then see to it that in accepting an occupation after that, he shall accept a position, no matter what the pay is, but a position in which to train better as an engineer, so that his training can become progressive until he is fit to start out for himself. I think this may be rather idealistic. We can do it in the army, and if possible in civil life so much the better. Of course, the engineer must be learning all his life long; and if he ever stops he should go into a box underground.

The supply we could get for the Corps of Engineers from West Point was insufficient. Then Congress authorized us to hold examinations each year and take in graduates from our civilian colleges. This we were glad to do. The first examination we held in January, 1912, and there were four men who applied for it from civil institutions and passed the physical examination. They all failed mentally but we were not willing to let it go at that, so we stretched our consciences very hard and took the best ones in. September 3, 1912, we had another examination. Sixty-six and two thirds per cent. of the men at that examination failed. In 1913, one hundred per cent. failed. In 1915, fifty per cent. in February, failed; in October, sixty-six and two thirds per cent. failed. In August, 1916, eighty-four per cent. failed. In January, 1917, we made the examination as simple as we could and thirty-four and one half per cent. failed. In June, 1917, the failures were eighty-one and one half per cent.; and in January, 1918, eighty-three per cent.

In 1916, after looking over the record, I thought there must be something wrong; so knowing the president of the Virginia

Military Institute, which represents one class of the engineering schools of the country, I asked him if he would put the questions given at the last examination before his faculty and frankly criticize them, so I would know if we were asking wrong or unfair questions. We put the same questions before the faculty of Columbia University of New York City. Both institutions said they were perfectly fair questions, and that any one who had learned the course ought to answer them all.

There is no question about it,—the courses of all the schools cover every question that was asked, and any man who had learned those courses thoroughly should have been able to answer those questions. Consequently, there was the inference that the students do not know what you are teaching; they never get it through their heads, and if that be the case, isn't there something wrong then with the kind of teaching? Is it not the case that after a professor has been teaching a subject for a number of years that subject becomes the end and aim of the existence of that professor, he teaches it as a finality of human knowledge, good in itself and requiring nothing further?

At West Point we were taught mechanics very thoroughly. We were taught it as we might be taught the Apostles' Creed, as a beautiful thing to live up to, but we didn't know much what it was about, and didn't find out until a year later when taught engineering. Then we found it had something to do with that, and, in the meantime, we had forgotten in part what we learned about mechanics. And so all the way through. The candidates of whom I spoke were good men; they came from good schools; they had had a very good course. The trouble wasn't with the men but with the way of teaching.

We have endeavored all through the war not to give a commission to a man as a combatant engineer who wasn't an engineer as shown by a diploma from a reputable school of engineering, or else by having been in practice over five years. No political influence came in play, and we prided ourselves on that. What was my dismay last fall when I found that they were going to graduate men at West Point after two years when they had had only a course of pure mathematics, and were going to commission them as engineers. I made the hardest kind of a kick and said that we didn't want them as engineers at all, and didn't want them in the corps; but for reasons undoubtedly good I was compelled to take them. So I was loaded down with sixty-two young men bearing commissions as engineers who had never been trained as such.

The next thing was to find out what we were going to do, and the only thing to do was to begin at once training them as engineers. Now it happened that due to the war closing suddenly a number of officers and graduates of the Academy became available, some of them our best men. So the only thing I could do was to form a course for these young graduates using these officers as a school faculty. I knew there were institutions where I could send them, a number of institutions were most kind in offering, but my young men had had a partial military training and I did not dare take advantage of the institutions; I wanted to keep on that military training for two years more.

That gave me an opportunity. I had been reading with the greatest interest Dr. Mann's report shortly before and had found a great many conclusions which he makes in that report were conclusions to which we had arrived in trying to find out why the examination results were as they were. So it came to me that I had a wonderful opportunity to teach engineering, wonderful not only for the sake of these young men but perhaps also for engineering training in general. So a school was started. We have no course in mechanics, we are not going to have any course in mechanics. We tell them mechanics is a very beautiful thing indeed, a perfectly delightful study, if a man has an income and can devote himself to research. But we are going to put up to them a civil engineering problem. We say this problem must be solved.

To do this, certain principles of mechanics must be understood, and as those principles come up in the attempted solution they are taught, not as an abstract science but as a tool which the engineer must learn how to use. And I hope before we are through to get up just as thorough a course of mechanics as is found in any of the schools, to be given in connection with engineering as a tool which a man must learn to use if he is going to be an engineer. Perhaps I can illustrate it.

In mechanics the first subject treated is naturally that of force, and the composition and resolution of forces. In the course at Humphreys the men are taken to a structure where evidently forces are in action, as, for example, a truss bridge. They are then directed to observe the bridge carefully, note its members, their forms, and the materials of which they are composed, and to try to think out why the members are placed as they are, and what fixes the dimensions of the members and the materials of which they are made.

From this follows naturally, a study and discussion of the composition and resolution of forces. This subject is considered first by the students in an apparatus similar to the Atwood machine. The relations of the component and resultant force and the lines of action having been determined by experiment, the algebraic formulæ showing these relations are then deduced.

Similarly a concrete example such as a lock or dam is taken. A model and drawings of the entire structure are exhibited, together with descriptions of the operating machinery. With this concerte example of work done, the problems relating to the forces acting upon the walls and the dam, with the laws governing them, are brought out. Questions relating to hydrostatics and hydrodynamics are presented, and after a study of the principles, the problems are solved. The reasons for the location of a dam, for its height, and for the effects of the dam on the regimen of the stream and on its navigable capacity are also presented.

The machinery of the dam and its motive power present many questions on other lines of work, all of which are taken up in their proper order in the course, and so throughout, the study of the principles of mechanics, including optics, acoustics, measurement of time, etc., is conducted with reference to concrete examples of work that has to be done. The interest of the student is stimulated and the knowledge of the principles is fixed by the immediate application of these principles to practical problems.

I hope by going through the whole course in that way we will get men more thoroughly impressed with the principles, in less time than is taken in studying principles in the schools separately, and cover the whole ground. That is the kind of work we want to do. And I am here with Colonel Peterson to get you to help all you can, on that line, because it is a most interesting experiment. It will be impossible to carry it out under the circumstances in such detail unless we have men who have kept their military training up, so there will be no waste of time and a perfectly clean slate on which to write.

That is what we are going to do, gentlemen. I have made this a longer talk than I wanted to, but this is an interesting experiment; we are going to try it, and we want your help. I thank you very much.

DISCUSSION.

J. C. Olson: I have listened with the greatest interest to what General Black had to tell us, and especially along the lines of the methods used at West Point, which consisted of giving the young engineer something to do every hour of the day, and the result which followed in efficiency from the military point of view, and also the implied criticism of the civilian college of engineering where we do not do anything of the kind and where it is my idea that we should not do anything of the kind.

Now, I do not for a moment question that the results attained at West Point are the desired results from a military point of view. I do not wish to question for one moment but that it is very desirable for the military engineer to be all things at any time he may be called upon and that he shall be ready to do any possible piece of engineering construction, whether he is fit for it or an expert or not—I do not question that for a moment, and that West Point is as efficient a military school as can be obtained; but the point I wish to raise is that in educating engineers for civilian work, we must be very careful that we do not adopt a military method, for two reasons; I think there are two specific reasons why we cannot go too far in this direction. In the first place, the real constructive inventive work is not done according to the clock; men do not proceed to sit down at a particular hour on a particular day and give you some original idea which is of value to mankind. Those ideas come at entirely unexpected and unspecified times, and the education which forces a man to do work at a particular time, that is not the kind of education which produces originality in men. I need only to cite the case of one of our great inventors who you all know will lose his sleep and meals and neglect every single consideration in his absorption in developing a particular problem. We have had criticism of our own school by students when set tasks to be studied within a limited time, that they are sometimes not ready to study, that their minds will not do their best work, and sometimes they want to keep on until eleven or twelve o'clock at night, that being the way their mind works. Of course, it is possible that there are times when men have to do things at a particular time and in a particular way, but I think there is a great deal of work which men do which they have to do in their own time and way, and if these men are given liberty in that sense they will do a good deal more constructive work than under military discipline.

I want to make one more point, which is this: I think the civilian colleges are specifically designed to produce experts and that it is a dangerous thing to develop the all-round engineer too much. There is a place for the all-round engineer, but there is a different place for the expert, and I think it is a very dangerous thing if engineers get into the habit of doing things they are not specifically qualified to do. I think a man should be trained specifically along definite lines; he should be taught them, not allowed to tackle things for which he has not made proper and due preparation. But I want to say that this is not a criticism of West Point at all, but to point out what seems to me to be a distinct difference in the requirements of education of the civilian college and for military purposes.

M. I. Pupin: Mr. Chairman and colleagues, I am inclined to disagree with the last speaker—radically disagree with him—not a little, but altogether. I have had something to do with West Point graduates and graduates of the Naval Academy. They came to Columbia to do some research work in engineering, and some of that work they did under my direction; and I found them way ahead of anything that I received from universities like Yale and Princeton, or some of the western universities—they were way ahead.

It may be, I must admit, that they were way ahead of the other men from ordinary colleges and universities because they were picked men—I admit that; but I also admit, and I am inclined to believe, that the reason they were way ahead, as far as I can tell, was because they were trained in the way —disciplined in the way that General Black described to us; that is, that they had definite military discipline.

It is a great thing to tell young men that there are certain things they must do whether they like it or not, and do it at the right time and in the right way. We are very deficient in all of the universities, I think, in that respect, and the adoption of a certain amount of that military—which we call ''military''—manner—I don't call it ''military'' because the word ''military'' does not seem to me very popular nowadays. I call it the disciplinarian method, and our work will not improve until we adopt a certain amount of it.

I do not believe that engineering education is to fit a man to do invention, to do original inventive work. Few students will do that kind of work, and they will do it whether they become educated or not; a man who is a born inventor is going to make inventions in spite of university training; he does not need it—he will make it; he will get his education and knowledge somehow. Engineering schools, it seems to me, are not called upon to take care of men who can make inventions, who have that kind of temperament; they are called upon to produce engineers, men of discipline, men who can do a job the right way at the right time; and that is the kind of men we want, men of discipline.

Now, there is another point—the second point I object to—training specialists; and I object to that more than I object to the first, if that can be possible.

Specialists!—Well, people ask me to-day, "Are you an engineer?" and I say, "I don't think I am." "Are you a physicist?" and I answer, "Well, I don't know; ask my friends, my colleagues, what they think I am." Now, really, I don't know today whether I am an engineer or a physicist or what not. I know that I like to be a scientist; I am interested in science—scientific research, and I don't care whether that research is purely of the scientific kind or purely the engineering kind. Of course, I must admit that I am an extremist in that respect.

Now, can engineering education prepare specialists? I don't think it can, because it is generally said that the few things a man can learn during his four years of engineering are so simple it will take a young man of original mind to find out what he knows—at least, it will take the conceit out of him. It is admitted by the best engineers that I know—and I know some very good ones—that our engineering education should pertain first to the fundamentals before you do anything else. and really, in my experience as a teacher of physics and mathematical physics, and theoretical and electrical engineering—in my experience I find that with the ordinary student, and even with the student who is considerably above the average, you cannot do much more than to teach him just the fundamentals.

Engineering is an art, and ''Art is long,'' as the poet has said and the gentleman said last night, and ''Life is fleeting.'' And if life itself is short, just imagine how short the engineering course in a university is, and you cannot expect to teach a man an art in a short course of four years that has to take care of the student and attempt to make him a specialist. It is absolutely hopeless. No, we don't want specialists, we want men who know foundations well, and then after they have left the university they can choose for themselves whether they want to become specialists or not. A great many, and I would say the best men I have had under me, do not intend to become specialists at all. They want to be good engineers, and the opportunities that they may get from time to time will determine whether they are going to give attention for some length of time to some specialty or another.

Professor Olson: When speaking of specialists, I would like to ask whether you mean that the man shall be an electrical, chemical, or civil engineer or all three of them.

Professor Pupin: I think labeling each man with a trade mark—electrical engineer, mechanical engineer, and so forth, has done more harm to engineering education than anything I know of.

K. G. Matheson: I wish to make a few remarks on the application of discipline as brought out by General Black. At the Georgia Tech we think we have done some little work, but when the Government placed there one of the aviation ground schools we at first did receive the cream of the teachers such as I had never seen in my thirty years' experience. And the marvelous application of those men was to be simply an eye-opener of the possibilities of the student life. I became profoundly impressed by the work done by those young men and the accomplishments under rules of efficiency; I wish to say that I have had the benefit of being trained four years as a cadet in my boyhood days, and I am exceedingly glad that I had that equipment. Although my life has not been along military lines in any sense, I am perfectly sure I was taught methods of discipline which have been beneficial.

At Longues, where there were twenty-two army schools, half of the picked men of the army being sent there for training (I have General Black's permission to mention the place as the war is over)), and, as stated, I have been a teacher for a number of years—through the kindness of the commanding officer I had access to all these schools and took advantage of the opportunity to see what could be done under stress or stimulus which the war called for; and I was amazed, literally amazed, by what could be accomplished under the stimuli of efficiency and of some particular impelling motive. The young men accomplished there in a few months almost unbelievable things. Of course, I recognize we could not have them continue under this high tension, but it seemed to me it opened up new avenues of thought as to what we teachers could do with our students.

Now, are we going to lose all the lessons of this war, all the high ideals of self-sacrifice and application? If we do, we are not deserving to live in this age. Those lessons of efficiency which these men have learned ought not to be lost but conserved. Many of these men are going back to college and the old slipshod ways. In my own institution, when we have chapel service the men come in singing and laughing and straggling to their seats, and it has been a joy to my heart to see the trim formation of the men going to places, no time lost, ready for business; and I repeat, the work done in those army schools illustrates what can be done with our American youth. Those were American boys such as you and I teach, large numbers of them college men, and with our incentives and typical American ideals and characteristics we do not wish to spend the time; our teachers do not wish it any more; we got deadly tired of the S. A. T. C.,—the faculty more than the students.

Now isn't there something we can do without having the extreme West Point idea on the one side or upon the other the slipshod, inefficient procedure of the typical American college. As has been suggested by Professor Pupin, why not call this efficiency instead of militarism, and train these young men along efficient lines? All of us know there is something beyond cramming the brain with theories of the textbook. We are training them for life; they will go into business. Their employers will not put up with what we do. Isn't it a mistaken kindness to let them go through upon the methods we have had, generally speaking, in the colleges? I believe myself that we ought to bend our energies toward something of the efficiency plan which these training schools of the war period have illustrated, and we ought to make a direct application in our institutions, and ought to omit our own feelings in the matter, and the well known antagonism of students, to overrule. And I repeat, that if we lose the lessons of efficiency in our colleges such as were taught by this war, we are certainly not faithful to the ideals of education.

I myself was very much in favor of the S. A. T. C. continuing in a modified form until July first. It would have been the first test we could have had in the colleges of this very efficiency of which I am speaking. We could not do it in the war period. The whole idea was to produce officers for the army in France. We had the opportunity from January 2 until July 1 to actually give the men this training, and it would be worth every dollar the United States Government put into it for efficiency, in training helpers who want to be leaders along industrial engineering lines and life generally. That is the best I can say of it, and now the point is whether we are going to do something to take advantage of what we have seen illustrated.

C. R. Dooley: That same thing took place, I think, in 147 schools whereby 130,000 went through, and the value of the discipline is not altogether to the man in charge of the school, because in his own institution the man has the problem of barracks. The military discipline which has been provided in Section B, not only provided an inspiration and exactness such as Dean Bishop has mentioned, but gave facilities for getting more done in a given time; it created a spirit of accomplishment, of production if you want to call it that; for joy of production, not for piling up the wealth of the country, but merely the joy of expression, and that came from the type of army officer which the school had, which was very far removed from civilian life, and he himself was an inspiration that he held out to these men that this was the way to the greatest accomplishment. It was not exactly the figure of K. P. duty which was always staring them in the face. I could tell you dozens of stories of the work of these 130,000 of men were trained in entirely different from their daily experience. A class of East Side New York garment workers and bums was far removed from educational ideals. In six weeks there came back reports of blacksmithing produced by those men which was perfectly wonderful; and last Thursday I went over to the Dickinson High School and they showed me piece after piece that these boys had made. Also the same thing that they buy from the factory, and you can tell the piece made by the boys, it was infinitely more accurate and a nicer job than the standard production.

That thing has gone on all over the country. As President Matheson said, what he saw in France has been done in our institutions. It is perfectly marvelous. Go to some of these schools, investigate the experiences these men have gone through and see what has been done, which would have been absolutely impossible except for this discipline. Don't call it military, but inspirational, because it appeals to these young men in production. In a very few short weeks there have been great results, and it has been a wonderful experiment and is something we must carry on.

C. R. Mann: There were perhaps a few remarks this morning that call for some comment. The question of general and specific training was discussed and various ideas brought out, one being that I was a great specialist, which seemed to be an implication of an argument for specialist training. Although I do not want to go into my autobiography, I would say that I went through college and spent nine years studying Latin and Greek and various things of that kind; also I spent a number of years learning to be a physicist, and taught physics for a great many years. Then I got interested in education, and that is quite a long call from physics to education. But the conclusion that I was a trained specialist in college does not hold at all; all I learned in the colleges was Latin and Greek, a little mathematics, and generally things of that sort. I think the same is true of Professor Pupin, whom I used to work under in Columbia. He was a graduate of Columbia, went abroad several years, and became an expert physicist. His specialist training took place after his college training.

Now, the issue is confused by the fact we haven't yet gathered the full implication of the war experience, because before the war, as you all know, our educational gatherings spent their time in discussions upon certain details; and we were divided into two schools, as usual. You know there have always been two schools, as Professor Hadley said, even in Noah's time—the diluvians and the antediluvians. It was so always; always divided into two schools on all sorts of minor points. That is, those who thought that the solution of education consisted in putting the real and practical before the theoretical, and others believed the theoretical should go first. I have now reached the conclusion that it does not make any particular difference, provided the boys want to do it. The fundamental point is to get the boys to want to do it. Sometimes it is advantageous to go from the theoretical to the practical application and sometimes from the practical application to the theory, all depending upon the skill of the teacher; in the individual it does not produce the effect if the boys really want to do it.

Now, the same is true with reference to this question about the general engineering and specific engineering, and it is perhaps fortunate that this discussion takes place in Boston, because Boston is not a place at all. ''Boston is a state of mind,'' and the engineer, in the same way, is not a specific individual in any way; the engineer is a state of mind, and the important thing is to get that person into the state of mind that is typified by the word ''*engineering*.'' There are different ways of doing that, and each school will find a different way, depending on the personality of the student, local conditions, the personality of the professor; and therefore we are not in a condition to lay down any general law with respect to the training except one—and this is the burden of my song.

We have all been amazed at the speed and intense success of the military training program all through, not only in the officers' training camp, but in the general and vocational encampment. Everywhere we have been amazed always at the speed and effectiveness of it, and we have said it was very noticeable the last two weeks—said it was due to the war spirit—the spirit of patriotism; and the minute the war ended there was a noticeable slump in the S. A. T. C.—the spirit of it. That shows us clearly that the only thing we can all agree on as the fundamental thing to try for is the same kind of *spirit*—and the problem is to transfer that war spirit of patriotism to a peace spirit of patriotism. Now, that puts a new face upon the educational problem, because it is not a question of intellectual methods, whether you go from amplification to theory, whether mathematics precedes science or vice versa; none of those old questions that we used to talk about at these meetings, but simply the question how to get the right spirit, and is it possible in times of peace to get the same sort of national spirit of service or anything like it that has developed in this time of national crisis?

Now, if we can get it, and it seems to me there is no theoretical reason why we cannot get it—if our young men have the spirit of national pride and service, and have them go to work in business with the same spirit as in war; if we can get that same emotional reaction, that is the question rather than any manipulation of administrative methods that we may devise here in all wisdom, and that is, I think, the fundamental problem before us. I think it is personally not only thinkable, but easily possible, to develop a national spirit of service in peace time, similar or perhaps as powerful as that which had its birth in time of war. And if we can do that we solve the problem, no matter of what kind of teaching methods we employ.

The problem, therefore, is an emotional problem, not an intellectual one. We have been talking about it all these years as if it was a problem in intellectual gymnastics, but you won't get a man fired with patriotism by any method of emotional gymnastics. So it is policy to recognize that it is also an emotional problem—a problem of setting up conditions that will appeal to the young man and make him feel inspired to real work and achievement and accomplishment for the national service. And I think the best line to follow in those conditions is a line of activity, namely, the line that deals with production. That is the fundamental keynote of our situation for the next twenty-five years; are we going to be able to produce not only goods, but men equal or superior to the men or goods in other nations, and how are we going to do it effectively? Young men are eager to express themselves in production, and the emphasis is not on mental discipline or training of the mind; the emphasis is on learning to do things for the benefit of the community in which they live. Therefore the machinery consists in each school of studying very carefully the immediate needs in detail of the industries and the general situation in that community to find out what to do to make that community a better place to live in, to increase its productive capacity, to make it a healthier community, not only in terms of material good, but in real human welfare. I think you can get communities interested in that sort of thing for their own sake, and in that way develop a spirit of community service, state service, and national service which will have a similar emotional effect to the effect of the war service.

Therefore, I would like to raise the question as to whether that is not, after all, the hub of the situation. It is no question whether the engineering school or the ordinary college have drills or otherwise; whether it shall teach mathematics by Euclid or some other form of geometry, but the question is whether you have the right spirit. Therefore we can gauge our educational discussion as a result of the war so as to include in its catalogue of operations the development of an adequate and refined national patriotic spirit; and I believe it can be done, and I am sure this Society will take hold of it from that point of view with great enthusiasm and great success.

A. L. Williston: I was very much interested in the two papers or addresses of this morning by Dr. Mann and General Black and the discussion which followed. It seemed to me in the discussion of General Black's address to a certain extent some of us lost sight of what we had in mind in this matter of military training. Forgetting the definitions that they both suggest, as I grasp the real essence of military training that has done such marvelous things during this last few months, it is not anything more than duty—an extraordinary willingness to make sacrifice, even to the extreme sacrifice, in order that that duty may be accomplished with a hundred per cent. perfection.

That is the essence of military discipline, and how any of us can have any difference of opinion as to whether that should be a part of after-war education is beyond my comprehension; and how any of us, either, can have a different opinion as to whether the methods that have been so extraordinarily successful during these months may not be useful in peace time in producing the qualities of character that we all have taken a part in forming. It seems to me it goes without saying that there is something very definite that can be learned from this experience, that can be incorporated into our systems of education.

There is a second point that General Black touched on—didn't dwell on, perhaps—that has not been referred to in connection with a part of this military work. I was at a meeting of mechanical engineers in New York and was much impressed by the paper of Mr. Wolff, on scientific management, in which he called attention to the fact that the best results that had been obtained were by appealing to the students to use their minds while they worked. If that is true, and if the general idea which he brought forward is true, that the best results are reached when mind and body are used simultaneously, then isn't there a lesson to us out of this military experience, namely, a fuller, better and more perfect physical development of the scientific with the intellectual? I think the response we have got from the efforts of these young men in these military times has been possible because of the wonderful physical development that has brought, first, physical enthusiasm, and then followed by mental enthusiasm as almost supplementary, or a sequence—the two things are almost of necessity complementary, it seems to me; they are methods that go hand in hand.

I was interested, too, in General Black's analysis of the combatant engineer, the statement that he came to be an all-round engineer prepared to meet and successfully solve any kind of problem that he was ordered to undertake. It seems to me that we are all of us combatant engineers, and that we have got to be prepared to undertake, at least, a wide range of business problems in life, and that there is going to be a good deal of uncertainty about those problems. Hence we have got to come with a broader conception of our calling and an understanding of a great variety of applications of the principles of engineering.

But I was interested also in his method of solution of that. He stated very clearly the goal he was after—the target he was shooting at. Then when it came to the sixty-two young men who came to him, he gave us a picture of the gun that he was going to use to reach his target. It wasn't general and visionary, entirely outside the range of both the interest and the comprehension of his sixty-two young men. His method of attack was to take concrete problems, not necessarily in hydraulics, I take it, but problems that were difficult problems, that were comprehensible to the young men of the age and experience that he was dealing with, but nevertheless real. One of the essential things, it seemed to me, in that method he gave as an illustration, was that the methods of education he was going to use there were methods that had reality, and it seems to me that the word *reality* is one of the things that gives us the key, at least, to the success all the way through of this military training program. And in carrying forward his instructions he was going to draw from that program things which had reality, and which had appealed to the interest of those young men—broad general principles, and he showed their application to a wide variety of other problems.

One point I, perhaps, would differ with Dr. Mann in the subject last discussed—I think really not with the point that he had in mind, but with the impression his remarks gave. He suggested that it made no difference whether the practical precede theory or vice versa. I think he will grant that it does to this extent, that theory can only precede practice where theory can be so presented as to come somewhere within the range of both the life experience and the interest of the individual who is to take it; and unless we can organize our theory so that it does that, then must follow the presentation of such practical problems as General Black gave.

Now, in nine hundred and ninety-nine cases out of a thousand we are dealing with the young and immature and have no background of real experience upon which to base theories unless we present to them in some such fashion practically real problems and draw our lessons of theory and practice from them.

The question of specialization versus general training is very largely one of difference in terms. Nobody, it seems to me, is interested in the kind of specialization that is not based on a broad foundation, of a thorough understanding of principles that may be applied in a wide variety of ways. But the danger, it seems to me, is when we agree that we shall avoid that narrow specialization. We are too apt to swing the pendulum over to the other extreme and say it is glittering generalities which have no reality.

In closing, I want to express my gratitude, and I believe the gratitude of the great majority of this Society, to General Black for that concrete expression he gave us of the way to accomplish the broad training through concrete and practical methods.

V. C. Alderson: I have come a long distance and I have yet to find out what I came here for; I have yet to learn the purpose of this meeting. I do not mean in general terms, I have heard that, and heard some very interesting talks; but I thought yesterday, as I listened to our English friends, that they had a method of their own which we Americans did not adopt, and that is the direct method. And I have decided I would take that as the first thought I would express to you, and I believe we ought to adopt that method immediately. If we all came here, as I did, with the idea that universal military training was to be introduced, and that we were going to do the patriotic thing in our engineering schools and aid the Government in the War Department, if that was our purpose, then we should take some direct action here before we leave, in order to bring that about. But I learned a few moments ago that perhaps that wasn't the plan, that perhaps the plan was for the War Department and the Government to do this training by themselves. If so, I am still in doubt, and more greatly in doubt as to why we are here.

Now, if the Government by itself has the purpose to do this engineering work by establishing more West Points or doing the work all by itself, Congress will pass the legislation at the suggestion of the War Department and we shall have nothing whatever to say about it. But, on the other hand, if we in the civil institutions are expected to do something, if the Government expects to use our institutions to provide a supply of men who may in future be of use to the army, then there is work before us. It is my idea that if that is the purpose of the meeting, if we are to join with the War Department, we ought to know it explicitly now, and if such is the purpose, we ought to be informed as far as we can be at the present time to just what extent we should have to introduce military drill, and to what extent we might expect to change our courses of study so as to conform to the needs of the War Department—change our courses of study to provide what our young men ought to know and carry into private life and be able to use in case of need. If the latter is the purpose of the meeting, I think before we close the discussion we ought to appoint a small committee, a committee of men who would agree before their appointment that they have the time, means, and willingness to coöperate closely with the War Department, and that course here means General Black, and, if necessary, go to Washington on call at the invitation of the War Department to confer with them; and also appear before the House and Senate committees on military affairs to inform them from the civil point of view just exactly what we can do, and make sure that legislation is put on the books, of such nature that we can all come in and do our part. Pardon me, gentlemen, for being so direct, but specifically I should like to have General Black or some one else tell us why we are here and what we ought to do, if anything.

President Hayford: Before I call on General Black, I think I ought to say a word on my own behalf and not merely as your presiding officer—especially in a case like this where the inference is (kindly enough) that we are here for one purpose while ostensibly here for another, or at least the purpose of the meeting is misunderstood, which makes it all the more necessary for the president to make a statement.

If anybody will look at the literature promulgated before this meeting, it seems to me that it is clear that this meeting was to meet the British Educational Mission and exchange ideas with them, and that commission was not on the face of it or in fact a military commission. It is the meeting of that British commission coming here in time of war to study conditions here, but those conditions are educational conditions, not primarily war conditions. If General Black will pardon me, I think I can sense the feeling of this Society and put across what I understand to be the real situation in a very few sentences. General Black made a clear distinction between the combatant engineers and those further back from the fighting line, the S. O. S. group, the engineers that carry supplies, those that deal with transportation, the construction of water works, and other problems back of the fighting line. I think I am interpreting him right when I say that his view of the training of the military engineer is that he is preeminently to be a combatant engineer, and that he believes that the training for S. O. S. service and other engineers is primarily a civilian proposition and wants it to go ahead in future as in the past; but he thinks the function of the United States Government in connection with engineers is to develop combatant engineers and, as I understand it, he is not thinking of any other kind of coöperation at present in the colleges of engineering, but in developing new and greater schools in place of the ones formerly at Willett's Point for the graduate work of West Point men who become engineers, and some school at the Washington barracks; it is a new and better school of that kind which he has in mind. If I have not interpreted the General aright, he has an opportunity now to make a better interpretation. I am trying to put it to you, sir, in your own terms what the purpose of the meeting was, and also what is the relation of General Black's proposed school to our schools.

General Wm. M. Black: You are quite right, and I am glad to answer what I understand about that matter; but I want to speak of one or two other things first and add to some of the things which Dr. Mann has said so much better, and which the succeeding speaker has put so strongly to you.

When at West Point there was a little man in my class fond of practical jokes, and he would get something off on almost every classmate. We were never able to get back at him because we could not worry him at all. He was a very popular fellow and has since risen to great eminence in the military career. Finally, when I was off on a furlough, I heard a bit of Sunday-school doggerel which happened to fit the case capitally—

> "Happy little Stumpy Wood,
> He always did the best he could.
> Let us follow Stumpy's plan
> And always do the best we can."

And then it stopped, because it *was* Stumpy's plan, and we got it on him in good shape, so that he became so exasperated that, picking out the smallest man in the class, he said, "I want to hear you get that off, because I am going to lick you and I cannot lick anybody else."

But, gentlemen, I am quite in accord with Dr. Mann and the succeeding speaker in the belief that what is needed and what we should do is just what we have been doing in this war, the development of the highest sense of duty. If you can get that into the man, that whatever they are doing is their duty, and it is up to them to do that with all their might always, you will have what you want, and you will get the essence.

Now, military training simply develops that and carries it out, and then puts a little machinery in to show how the whole thing will work more coördinately and smoothly. But that is the essence. If you can get young men to come to school for a purpose and learn to be true to themselves, true to their family, and their country, they carry out that purpose—in other words, get that sense of duty and act on it, and then you will have the spirit that will make it possible to do anything. That we must instil into our young men if we can.

One gentleman this morning spoke about invention and about the necessity for the inventor to go off and dream and evolve the bright idea, and then come down from heaven and place it before the world. There is not one of you who has been educated in a great engineering school who has not been compelled to invent, no engineer who has had a great work to perform that has not had to make improvements on existing methods. They don't come from dreaming, but in doing the work and seeing how each can improve on what has gone before.

We have had the other type of invention or inventor to deal with, and you may thank your stars—all except Professor Miller—that you haven't had anything to do with it in this war. Professor Miller has had, and the Department at Washington has been simply swamped with the other kind of inventions—things called inventions, because they were new to the inventor; but things thought of by Alexander the Great and his generals a long time ago. Much time of the men in Washington and in the United States at large has been consumed absolutely uselessly in this war by so-called inventions, and a bigger nuisance than the ignorant inventor never walked on two legs. I say "ignorant" inventor, because almost all these things result from the fact that the man didn't know engineering history and he didn't know military history, the conditions of engineering as existing at the front, nor the conditions of the war; so he would come along with things that looked very good to himself and his friends. Professor Miller has been through it, and we all have down there in Washington.

Now, that kind of invention is utterly of no good to humanity. Edison doesn't work them out that way; he has had certain problems and has been doing his best to solve given problems, and in thinking them out his original mind took a step farther than any one else has done. That is invention; that is the way inventions in the world come about.

I spoke about making specialists, and subsequent speakers, Dr. Pupin, Dr. Mann, and others, have said that specialists are needed, but for heaven's sake! don't let them specialize until they know their business, until they have such a clear appreciation of everything leading up to that specialty that they can specialize and do work for the world. The other kind of specialist reminds me of a story that happened some time ago. I went to a very prominent sanitary engineer one day, whom I knew very well, and asked him at what stage of his career a man could call himself an engineering expert. He replied, "Just as soon as he can charge forty dollars a day and expenses and get away with it." That is the way with a good many specialists of the other kind, we don't want them. A real specialist has a broad knowledge of his profession in general and then goes ahead on a particular line and works out something good. We all have to be specialists at times. We have to be specialists in making inventions, we have to be specialists in making steps forward, but the best step for the benefit of the world and the best way to do our share towards paying the debt we owe to our predecessors in engineering is to go right ahead and develop in any work the thing that comes up, and go a little further if we can than had been done to date, and we all have to do it.

Now, in regard to this meeting. The president is entirely correct. Neither Dr. Mann nor myself came to ask anything in particular of the schools in regard to the immediate needs of the War Department. I happened to mention this morning that for the Corps of Engineers in all human probability we shall have to call on the engineering schools of the country each year for a certain number of men for our Corps, and I tried to describe the kind of training we would like to have those men receive. Then my other remarks on that were somewhat in the hope that we could increase the comprehension of our young men as to the fundamentals of engineering, and I told you of my doubts as to the moment of inertia and also that I had found that other men had their doubts, that there are a lot of these principles only partly comprehended. They are not so abstruse that you cannot learn them at all, but simply that they are not presented in such a way that the young man can get hold of them, because their interest is not excited or they are presented in such a way that they cannot quite grasp them. And if we could improve our methods so as to get that better, it is simply a saving of time, getting more done in the same time.

Now, gentlemen, if you will look over the courses you have all been through, you must recognize that there are at least four or five years of a young man's or a young woman's life wasted. Consider one thing, for example. For the first seven or eight years of a child's life he is worried with arithmetic. Generally he doesn't get much out of it. I think I must have been twenty-one years old before I fully comprehended why, in multiplication, you set the figures as you do. There are a whole lot of things of that kind, and when you get on a little further you feel exactly as if, in putting you through that long training on arithmetic, you had been given an axe and told to chop down a tree with the blunt end of it; because you find a little further on that you have been given an exceedingly poor tool. Others are infinitely better, and you wonder then why those who had charge of your education made you work years and years in learning processes you simply turned into the scrap heap. Why not teach mathematics? Why teach arithmetic, algebra, trigonometry and all the rest separately, and not use all progressively as the more intricate computations are reached, using for each class of problems the mathematical process best suited for it? Why not give a proper tool to the child at the moment when he can use it? Children are scared at algebra because told it is advanced mathematics, but it comes nearer to the child's attainments than anything I know of, because it is a beautiful game of make-believe all the way through. Why make a bugbear of algebra? Why bother with cube root and the higher roots by arithmetical processes? Nobody would dream of using them. Take the algebraic methods and learn logarithms and you dismiss all those stumbling blocks which simply discourage young students. What's the use?

Now, let's take that right into our higher education. Stop teaching a lot of things. It is like giving a child a certain number of treasures which he puts in a box and sets them up in the cupboard, and says, "I am through with them," and when he hunts for them he has lost the one he wants the most. Why not make it a progressive system from the beginning right straight through, and then we will get what we want. You know in our country, by the time a man reaches twenty-one to twenty-two years of age he must be self-supporting; therefore you cannot give more than so many years for the fundamental training. Then let us become sufficiently efficient in our educational methods to enable us to give in those years before twenty-one or twenty-two the training he needs. It can be done, and it is simply up to us to give way to proper efficiency methods. If we get them, and then instil that sense of duty, and its practice all the way through, we will get the product we need for the nation, and the product that is needed for the world.

Professor Olson: I think you will permit me a word. It seems to me I have started something. There has been a great deal of objection to what I said, but I think there have been a lot of good things said since I made those two points and I agree most heartily with what General Black has been telling us, and with what other speakers have said. Of course, I had no idea whatever that the man should dream and present his dreams as something that was born complete. I realize as well as anybody that the matter of invention is a matter of hard work; I have done enough development work myself to realize that after ideas come it takes hard work to make them practical.

But the point I made is this, and I don't think anybody has touched it in the discussion, and that is under the military method as we had it in the S. A. T. C., the young man was given definite hours of study and just exactly the number of hours in which to do his work, and it appears to me that for the civil college, no matter what is true of the military, that that plan will not result in efficiency so far as study is concerned. I may be wrong, but that is my belief, and I think more discussion should be devoted to that phase of the subject. The student does better work when he is put upon his honor, when his interest is developed, and when not told specifically that he must study from seven to nine or any other particular time.

I believe in the promptness of military work. There is no one more irritated than myself if a man or a class comes in at intervals of two, three, or five minutes. I believe in starting on the minute and closing on the minute. I am in sympathy with the military regimé which when it says eight o'clock means eight o'clock; I absolutely believe in that. And I think we can get a great deal out of this if we will insist upon that in regular college work. I think it is going to be an improvement and will help us very much, indeed; but when it comes to study, if a young man is told to get his lessons and put time enough on it—then let him work his own time, as long or as short as necessary. When I was in college, some lessons could be prepared in half an hour and others in three hours, and I never found in my experience that fixing a definite period for class work was the right thing; if I had the details of getting the subject, that was the point.

And the same idea in original work. I do not think General Black speaks about any definite hours, that the work is in mind and it has to be done, no matter what the hours are and how much time it takes. Now it appears to me that the young man doing civilian work is not going to be under the same military rules in his work. I think the same thing will be inculcated if he is given more freedom, and with that freedom he will do better work than otherwise. I am very much in sympathy with the present concrete problem that is on the board in front of us; I think that is a very great thing; I think there has been too much of the theoretical. On that point I am with the practical, that is, with the concrete and the definite aim in education.

As to specialization, I have in mind whether we are going to drift back again towards general engineering education, or whether the policy should be taking the freshman class uniformly in all courses and then dividing it into various groups. Is that the proper procedure, or is it not? Have we gone too far in that direction, and shall we come back again? Now I do not think those two things have been discussed, and I would like to hear others on those two points.

C. F. Scott: One of the first statements in regard to Dr. Mann's address this morning, one to which I might take exception, was that experience of the S. A. T. C., that it was too short to give us any lessons or give us experience that we could draw conclusions from. Short as it was, and unsatisfactory in many particulars on account of that shortness, there are, I believe, certain lessons which we can learn, and I have noted two or three points which I suggest to those present may be brought out this afternoon. One is in the supervised study the reaction on the teacher. The teachers have come in contact with the student during his study and preparation period and have got a new viewpoint of the difficulties of the student, upon the way he is studying and have found out some of his mistakes in his methods of studying, and have come to realize more that the preparation period is something the professor should keep in his mind in teaching students how to study as well as calling upon him to recite.

From the standpoint of the student the supervised study has given to many a new notion of concentrated definite and earnest work in a measure that they have not had before. We have had, in addition to our regular undergraduate students, a number in the officers' training group of the Signal Corps. They have been men from various parts of the country, and some of them have told me that this concentrated training they have been getting has given a new notion of study; that they had not been good students in the first years of the college course; that some of them left when halfway through college, but if they go back it will be with a different point of view; and I think the same reaction has taken place in the undergraduate students.

In connection with the S. A. T. C. and war work we have had a splendid example of one of the things that Dr. Mann puts forth in his report, namely, the value of interest as an incentive to work. What happened at the time of the armistice simply reinforced that whole proposition, that the interest and incentive are the strongest things we can have in education, and Dr. Mann has done us a splendid turn this afternoon in suggesting some methods by which that interest can be continued in the future. Incidentally, at a meeting of one of my classes last week, I put the proposition to them that the change we are going to make from the S. A. T. C. to something else was one that might well occupy their attention, and asked them if they would not like in the discussion next week to take up the questions of the last few months, what they had gotten out of it as students, and what things we had had in this late experience that should be continued and would be valuable; that it was a very important matter to them as Juniors to find out what methods of work during the next year and a half would be of the most value to them and have important bearing on their careers through the whole of their lives. They took an interest in it and said they would like to discuss it and will report in a few days after reviewing the situation.

Dr. Mann stated that one of the purposes in the educational training of engineers was to train them for the handling of national problems; that one of the great difficulties the past year or two—in the aircraft, particularly—has been the handling of industries on a large scale; we needed nationalization. The attempt of a great many in the industries of the railroads has been to bring that about, and the business of the Government for many years has been to prevent that; the Government for many years undertook to separate the railroads. Take, for example, the Union Pacific and the Southern Pacific. It got that organization, which ranks as showing the highest efficiency of operation, and one of the highest in operation from the point of safety in the country—separated, and then the Government came to undertake the same problem of national transportation which the railroads had in a measure recognized, it immediately called together the very men they had tried to put in the penitentiary for doing these things, put them at the head of the men to operate those two railroads on a national scale; and that wasn't enough, but they took over the railroads themselves to operate them by some of those very men whose railroads had been separated. Now, Dr. Mann, you mean to say that we should train men as engineers to teach them to operate in the industries, particularly the railroads and thereafter become criminals in the United States? It is to be hoped that Congress as well as the engineers can draw some lessons from this war. In point of discipline, this new method which we found so efficient in many ways, how to continue that in the future is a problem. Strict discipline, holding the young man to a definite course, has many admirable features; it keeps the student from doing wrong; it strengthens them in certain good habits, but when those surroundings, limitations, and rules are removed the man may not have the strength of self-control and self-dependence which he would have had if they had been cultivated during these periods when he has been protected. There are dangers both ways—too much protection and of not enough. Where shall we draw the line? How far shall we go, and what instrumentality shall we use in the college with students in the future to continue this desirable disciplinary method? That is one of the large problems which is before us, a problem which the stopping of the war has made greater than that of starting it; the problem of getting back into a new life of the future, one which probably is as important for us to solve and solve right as that of getting into the war right.

Some of the things said this afternoon reinforce this proposition which is one that I would have presented anyhow, that somehow the problems of peace on the conduct in the ordinary life of men in overcoming and solving the problems of living, of overcoming problems which nature presents and solving nature's problems, are those which should involve some greatness of ability and preparation to work out, the same as the emergency problems of war. If we are looking forward to general usefulness and proper development of the race, war is simply preventing a catastrophe, but the constructive building comes in the future, and the keynote of the problem before us is to get into the state of mind to cultivate men's interest in something definite and tangible and real which is going to make our schools not ideal, not general and vague and indefinite, but concrete and real. A good deal of this discussion between that which we term, on the one hand, as generalization, of course is specialization, or as broad engineering training against specialized training, or as ideal versus the real, comes down really to the difference between the abstract and the concrete. We don't want to be so general that we are vague; we don't want to be so special that we are training as specialists and artisans. We want to lay the foundation in broad training, to get that broad training not by going into the vague, the abstract, the theoretical, the ideal, but by combining that and learning those things through that which is real, concrete, specific, and which the diagram on the blackboard is a good illustration of.

President Hayford: If Dr. Mann has anything to say as to why he advises men to become criminals, perhaps we should like an explanation from him.

Dr. Mann: The case Professor Scott presents is the very case of the fundamental problem that the engineering world has to face, and I purposely have so far avoided discussing that because I did not want to confuse engineering with the local issue. However, if you want my personal opinion in that matter, I will be glad to give it.

There was a significant statement in the aircraft report, in the summary, which says that the criminal statutes do not reach cases of inefficiency and therefore these gentlemen are all absolved. Now, in the case of the railroads, it was found that the engineering solution of the railroad problem was diametrically opposed to the legal solution of that problem a few years before, and the most interesting question, it seems to me, before the country so far as engineers go is the adjustment we have got to make between the legal solution of difficulties of that sort and the engineering solution.

Now, the legal solutions, it seems to me, were made to prevent people from doing certain things. They were negative. They were not there to encourage efficiency of the railroads, to make them serve the nation better, but those legal restrictions were placed there to prevent people from doing certain things that the country considered to be unfortunate from the legal point of view. Therefore all I have to say is that the antithesis that the engineers must make in the next few years between the legal solutions that have been put forth and the engineering solutions that must be forthcoming is going to present a very interesting field of activity for engineers; it is going to get you into many very inspiring arguments and discussions.

Now, that point I have not dealt with in my report at all, because again I do not want to confuse strictly the educational issue with what is the very fundamental issue in industry—the issue of whether the industry is to be controlled by legal enactments in the interest of those who hold the title to the plant, to the tools, the legal title, and those who understand how to use those tools. I don't want to confuse that issue with the strictly educational issue, but it is there and you will have to deal with it sometime, and it may appear, therefore, that some engineering solution that we adopted primarily in the war—because the engineering solution is the one for production—may contravene what has been set aside as the legal solution for the difficulty.

Edward Robinson: There is a thought that has come to me in listening to this discussion this afternoon. We all, I think, can agree that we want to get the splendid disciplinary training which the military training gives. We want first that vigorous health, that erect form and splendid physique; we want clear thinking and fundamentals and all that sort of thing, and this military training has succeeded, to a certain extent, in doing that. But it seems to me it emphasizes a very great lack, and we all want to clearly look at that lack, in our whole educational system, and that is that the time to do that is not to begin it in our colleges. You can take a piece of cold iron and hammer it into a given shape, but if that iron is heated you can hammer it into that shape much easier.

Now, the time to begin this military discipline, that care of the body, that personal development, is when the boy reaches his social stage, that is to say, when he is from twelve to fourteen years old; so that by the time he gets into college those habits will be thoroughly formed, and I believe we college educators have got to look at that side of the matter and in this reorganization that we are trying to bring about also try to work for this discipline down in the lower schools; because if we can get it down there, we can save enormously and make our work tremendously more efficient.

Now, General Black has suggested something under that line in the matter of teaching arithmetic. I know perfectly well that to a boy of fourteen algebra is much more interesting than arithmetic; I have simply been through that experience in the last few years with my own boy. The same thing is true of the teaching of language. The time we waste on arithmetic in those lower schools, if we put it into good and thorough training in the spirit of language by letting the child study his Latin and his other languages, he would get that language training that he never gets afterwards—if he does not get it at that time. I believe that we want to get that spirit of the military that we have all seen. We have seen these boys get out of college and go into the training camps and come back splendid specimens in a short time. But there is no reason why we should not have most of those fine and vigorous personalities when they enter college, and if we can develop their interest it seems to me we have got to start down below; and that in this Government committee, if it is going to hold on to some of these things, we must consider the earlier type of training, too.

Dr. Mann: I forgot to answer another one of the questions asked a few minutes ago, but I do want to answer President Alderson's question about the control of schools from any central federal agency, or the request of the Government in regard to what schools can do—any organization that might be effected further on in the work of our committee or any other committee that might be established. Because I think it is very clear to every one in Washington as well as here that any form of Federal control or federal dictation of our national institutions in the country would be a mistake. It would be undemocratic and a very dangerous thing to do, therefore I don't believe that Congress will take any steps in regard to universal training that will impose upon the school system of the country any restriction. The school system of the country must be controlled locally and by the states in order to be safe, and I am quite sure as far as our committee is concerned we have no idea whatever of trying to prolong the guidance or the control of the schools placed in our hands for a few months on account of war necessities. In times of emergency you can do that for a short time, but it is not safe for a general policy.

Now, it is not proposed to train schools entirely without any advice. We are planning and hoping to be able to carry out a project of gathering together the vast mass of material which exists there in Washington of experience with this work, showing the type and problems that have had to be solved and met by engineers, and perhaps it is possible to get that material printed and distributed to the schools for their information, and the schools can do as they like with it, there can be no possibility or desire of ''Thou shalt'' going with it. That makes it perfectly clear, to my thinking, that the progress of engineering education and the development of the nationally thinking engineer is squarely up to the schools. The Government has no authority to take control in that matter. That is my own personal opinion in the matter, or it is the opinion of our committee if you like. It is not, of course, Federal judgment in the matter.

So it seems to me that all ought to think of it, not as a matter that the Government is going to assume the responsibility. It is going to be the Government's place to guide and solve this problem and tell you what to do. Not at all. The problem is squarely up to the schools; on them rests the opportunity; upon them comes the burden, and upon them rests the responsibility, it seems to me, of finding the solution.

President Alderson: The reason why I put my question sometime ago is this: In the state of Colorado there were three institutions that had the S. A. T. C., and in the first one the president of the institution was told that he had nothing whatever to do with running the institution; that the commanding officer had to do that. He remained, however. In the second institution the second president was told that he didn't have anything to do, and the matter was reported to Washington, and the officer was removed. The same thing happened to me; I did the same, but the S. A. T. C. died and he is still there.

So far as institutions are to do this educational work in aiding the War Department, I want to know, first of all, what the contract is going to be; I want to know if the army officer is going to interfere with the academic work and report only to the War Department. Tell us who is the head of the institution. Do the trustees, the faculty, or the president amount to anything, or whether he is going to be a member of the faculty and subject to the rules of the trustees?

Now if there is going to be any military instruction in the engineering school, I think the status of the army officer should be distinctly marked out. In Colorado we have had a very bitter experience, and if I were to be asked at this meeting whether we wanted any military instruction, I would ask if it is going to be under the S. A. T. C. or on our own account. If it is going to be for harmony and good feeling and work for our common interest—yes. I think that matter is a vital one, that anything done by the War Department with reference to the engineering schools should be looked at as a vital matter and taken care of. For instance, the exact status of your commanding officer, and I speak from bitter experience. In the latter part of September I knew of the status of a second lieutenant, a man with no training or culture and no judgment, who was sent to our commercial institution to command everything in sight. If that is the kind of a man we are going to have in the future, I don't think we want any military instruction in the school. But if we can have harmony and a gentleman of experience in training, willing to coöperate with us, then I think we ought to take hold and help the War Department.

It was with that idea in view I asked the question, Why are we here? Let me say that the printed instructions in regard to this meeting are very clear, but our British friends have gone, and you will remember we were to devote this afternoon to this Reconstruction topic. My question still holds; will somebody answer it? Is this work to be carried on by the Government alone, or are we in the engineering schools to be asked or commanded to come in, too, and if so, how?

President Hayford: I would suggest that the answer of the group is being given in a very successful discussion; all the discussion, both this forenoon and this afternoon, shows what the sentiment of the group is.

R. C. MacLaurin: I cannot get away from attempting an amusing statement—amusing to me, anyway. For years when I was a youngster I wanted to be a general, but I got over it. Now, for the last four years, I have certainly wanted to be a soldier, and since the eleventh of November I have gotten over that; but since hearing President Alderson's statement about whippersnapper lieutenants who were able to talk saucy to college presidents, I am on the band wagon again.

President Hayford: Earlier in the discussion the idea came up several times that a real military training is very valuable as a means of promoting efficiency, and I am tempted to suggest that Major Gilbreth, who looks at things from the point of view primarily of efficiency, should tell us in a few minutes what he knows about it.

F. B. Gilbreth: I am glad that he said a few minutes, because that is the only thing that can stop me.

At this War College I worked with two or three very fine young men who were trying to put the one best way into moving-picture films, and they tried to standardize the one best way of the best teacher. You have been talking a lot about pupils, and in their behalf I desire to talk about their teachers. I think you are a sorry lot; I think that you do not dare to face the facts; I think this is a mutual admiration society, where you come together with the idea of stealing half of the wrong idea from each other. I dare you to come out and agree on some one single thing; reduce this problem to those points where we can agree and then let's argue one point at a time.

Discipline. I will tell you why you haven't got any discipline over your boys. They are "on." In the army they may be "on," but they don't dare to stay "on." They are "on," that is why you haven't got the discipline. When the boy absolutely believes that his teacher is right, there is no trouble about discipline, and if you have a definite scheme of presenting before those boys the one best way on minute things so far as you can agree, the discipline will take care of itself. If you wish to try out some discipline, go into the entertainment room where there are a few rogues and roughnecks and talk to them on a military problem and see what will happen to you. I had that experience at Fort Sill and got away with it, and I will tell you why. We took a picture and put it on the screen, and we had a projector which wasn't merely a projector for motion pictures but one that would also permit you to stop on any one picture, permit you to run backwards, and permit you to treat the consecutive snap shots as lantern slides. And I said to these young men that I had a long experience in recording the one best way and these pictures were made by experts in their particular department and these pictures had been shown to competent officers and revised by the best men and improved under their criticisms and they would be good for them to see, for sooner or later they would go to France and would like to know these things. They didn't haze me at all. They took me into their confidence and wanted to talk it over. I laid myself liable to a terrible hazing because I was neither a military man nor a mechanic.

Now, if some of you don't start in on this scheme of the recording of the one best way so that the rest of us may have a target to shoot at, as one speaker has said, I shall do it myself—in fact, I have already done it. These pictures at Fort Sill are so good they have been copied by a number of people, but they are not entertainment moving pictures, and they are not the so-called educational moving pictures.

In this matter of recording the one best way and in standardizing it, that is a trade in itself. We have got to have experts in that work. I brought it to the attention of this society six years ago—naming the possibilities of it without going into the details, and I have now got a thousand feet of film. I notice your long list of committees, but I see nothing that resembles a committee on the standardization of the one best way, or anything that suggests that the whole scheme of teaching engineering consists in the perfection of its parts. I agree with the previous speakers that we should give them a broad education so they may be in a condition to do as a friend of mine was willing to do who was offered a job in Alaska one summer. I asked him if he could do that particular form of engineering. ''Where is it?'' he asked. ''In Alaska.'' ''Oh, yes, I can do any kind of engineering in Alaska.'' ''Why?'' And his reply was—''It takes eight weeks to get to Alaska.''

Anson Marston: I am afraid you will think it is frivolous when I tell you what it was. I told him I thought I could illustrate the war in education by influence on the educator. You will note this uniform which was made by a tailor, and I will state that I measure three quarters of an inch taller than I did when I went into the room; I hope that the war will have the same effect on engineering education, that it will bring it into stricter limits of the essential things—shrink it, for instance; and that it will place it on a higher plane.

W. G. Raymond: I do not recall whether any one has said anything in favor of the S. A. T. C.; if any one has, I thought perhaps I would like to roast the army a little by speaking in favor of that organization. We had the usual experience in Iowa; we had a rather incompetent commander, we had incompetent young lieutenants in charge of our companies, and we had the influenza; we had over a thousand men sick and thirty-one lost. We had to establish our own kitchen arrangements, and it was supposed to be our own fault in not being able to obtain sufficient labor, so that our men had to do kitchen work.

At times I thought the institution was a military post, so that the men had to do general police duty, which took considerable time and a considerable number of men, and the men didn't get to classes when they should at times. But in spite of that, during the last two weeks, particularly after the signing of the armistice, when most people thought we would go to pieces, we had the best work from our students I have ever known our institution to have in the time I have been there. There wasn't any question about their appearance, no trouble with discipline; they appeared in the classes on time, and during the study periods assigned they were in attendance and they studied, they were interested in their work, and there was no difficulty whatever, and the general atmosphere of the institution, in my judgment, was much superior to the atmosphere that has prevailed there in previous years.

Now, in regard to what is coming—I don't know what Professor Olson's question was which seemed to refer to what might develop in a military sense hereafter. I can only answer that we have had military training in the school for a good many years and very successfully. We were particularly pleased with its development under reserve officers for the training corps, and we expected to continue after the manner of the S. A. T. C., and we hope that it may be even more distinctly military than it was under the former organization.

Colonel Peterson: I have very little to say. I told Dr. Hayford coming up on the train that I wasn't coming for the purpose of making speeches telling how this education should be done. I have been so busy during the time, trying to get information, that I have not thought of anything I might say this afternoon. I realize this S. A. T. C. has got a lot of unfavorable comment accorded to it. No one seems to care to stand up for it. I don't know as I care to say anything concerning that, only it was a very difficult situation both for the army people and the college president, and it was unfortunate for the army officers that the matter was forced upon them; and the officers called back from the service, when not familiar with it. I am sure it was quite as distasteful to them as to the college authorities. It is a very difficult proposition to handle—very difficult to discipline men when under your control for only a short time. There are many things that make it difficult to handle also when you share the responsibility with people that do not thoroughly understand what you mean in the carrying out of the proposition. I think that is all I have to say.

President Hayford: We have a few minutes left to continue the discussion.

Professor Scott: Weren't we to have a part of our meeting devoted to the matter of research?

President Hayford: That is naturally a part of the reconstruction problem.

Professor Scott: From some things said this morning, I feel there is a good deal more I would like to hear on the subject.

President Hayford: I think it would be interesting to those of us here to have some discussion on that question. Is there any one who wants to take up that matter?

Dean Marston: The meeting which was called in the other room was called by President MacLaurin, to consider some legislative proposition to establish engineering experiment stations by federal aid. At the meeting the Smith-Howard bill, which is now before Congress, was read and discussed by Professor Pupin from the Research Council, who offered a modification of it. The bill proposes federal aid from each of the states to be distributed to the amount of $15,000 per year; afterwards to be increased to $30,000 per year, as determined by the Legislature.

Professor Pupin proposed a wider measure, a modification of it, by which a board of scientific men would be created in each state to direct the use of the federal funds which would be according to a plan by which individual research men might be endowed or research be carried on at specific institutions.

The meeting was for a general discussion which was very active, and a very significant addition to the meeting was made by President Hobb who presented the view that it was as vital to all the schools as to the engineer. The meeting closed by adopting a general resolution favoring federal aid for research and aid of as practical a character as possible.

If there are any questions, the president of the Georgia School of Technology is here, for it was by legislators in his state that the measure was introduced into Congress; there are also present Professor Howard and others.

Dr. Mann: Who controls the thing in Washington?

Dean Marston: The Smith-Howard bill in the Bureau of Standards modified by Professor Pupin.

Principal Williston: Isn't it important that the Society as a whole should endorse the resolution? It would have more weight in going before Congress. I would ask Dean Marston if it is not desirable for us to hear the resolution and opportunity be given us to add our endorsement to that of the committee.

President Hayford: If that should be desirable it can be readily done.

Principal Williston: I would make that as a motion.

President Hayford: This movement started at least two years ago, possibly three—at least two. It was under active discussion; there were special meetings held to discuss it, and there has been a considerable amount of discussion of it outside this Society. There has been little or no discussion of it inside the Society. It seems to me, therefore, that putting it as a question to this Society for us to take action as a society would be to take action on something we have given very little consideration.

K. G. Matheson: The resolution was of a very general character. It didn't favor any particular bill or any amended bill, but simply was as has been stated, that those present favored federal aid to engineering research stations, and that the best bill possible to be presented was the bill that this gathering favored.

There are to be, as I understand, several meetings of engineering societies next week, at which this whole question will be very carefully considered, and it will be exceedingly important for this body as such to put itself on record as favoring federal aid to such legislation, without reference to any particular bill. It would not require a great deal of discussion for us to put ourselves on record in regard to it.

(A motion is made to that effect and Dean Raymond reads the resolution adopted at the noon meeting as follows: "The Society for the Promotion of Engineering Education, now assembled, expresses its approval of Federal aid for engineering and scientific research in the United States.")

(This in the form of a motion was presented to the meeting and a unanimous vote was passed in favor of endorsing the resolution.)

Mr. Whitney: This question is a large one which cannot be discussed in open meeting successfully; it is a matter for study, for careful investigation; it is a matter for public information; the public have got to be informed, so that if any of you can write and get it before the general public, that will assist in getting it before the United States of America. And there is one thing that Mr. Gilbreth said which has made me say what I am saying to-day. The more highly educated the individual is, the more difficult it is to get a group of men down to doing the practically obvious and simple things, and the tendency to postpone difficult things to some other time. We see difficulties on all sides, and cannot we get together and agree on some fundamental scheme, postponing the more difficult things, and then we shall get ahead.

EDITORIAL.

We are gradually returning from our various war occupations, or from teaching under abnormal war conditions, to our regular work in the colleges of engineering of the United States. By October, 1919, the colleges will be in full and normal operation with students attacking their problems with renewed vigor and in many cases with an awakened and keener vision of what they may get in college. The coming year brings an unusual opportunity to tone up and strengthen engineering education.

The war conditions and war experience have shown us but few things that it is advisable to imitate in our colleges. But the novel conditions and experience have stimulated thought. We have seen old things from new directions. Many virile suggestions as to possible improvements in engineering education have come to us.

At the Boston meeting of the Society for the Promotion of Engineering Education and the British Educational Mission in December, these things were increasingly evident. Though the program was radically changed by accident at the last moment, the discussions, necessarily impromptu in character, were vigorous. At the end of the two days of formal meeting a mere passing of the word that such a gathering would occur brought together two dozen men who exchanged ideas informally and freely for three hours on that last evening. Those three hours revealed to every man present new views, a new vision of how our thinking had been stimulated in such wise that now is evidently the best of times to discuss our common problems.

The Mann report on engineering education has appeared opportunely, just when war conditions have helped to jar us loose from set ideas. Its suggestions fit well as a rule with the war suggestions. No doubt this report will be studied and discussed much between now and June in our various separate college groups.

The war experience and the Mann report considered deliberately for a few months, the automatic tendency now to reconsider old conclusions, and the opportunity in 1919–20 for a college life of renewed vigor, all furnish a basis for a June, 1919, meeting of the S. P. E. E. (probably at The Johns Hopkins University) that shall be the best for years in live discussion, in informal exchange of views between formal meetings and in renewed acquaintances.

You ought to know what others are thinking. Others want to know your conclusions.

This Society is unique in the vigor and directness with which it deals with the problems of college education,—perhaps absolutely unique in the United States in dealing with the fundamental problems of college education as distinguished from college administration.

Make your decision now to attend the June, 1919, meeting of the S. P. E. E. Let us gather new strength and inspiration there to help us in our endeavor to make engineering education the best college education to be had in the United States to fit men for service.

THE OFFICERS OF THIS SOCIETY HAVE OPPOSED INCREASING THE DUES, ALTHOUGH IT HAS BEEN SUGGESTED BY VARIOUS MEMBERS AT DIFFERENT TIMES. IF EVERY MEMBER PAYS HIS DUES PROMPTLY THERE IS NO NECESSITY FOR SUCH ACTION. IF YOU HAVE OVERLOOKED THIS MATTER, WILL YOU NOT ASSIST THE SOCIETY BY SENDING YOUR CHECK TO THE TREASURER, MR. W. O. WILEY, 432 FOURTH AVENUE, NEW YORK, N. Y.?

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., MARCH, 1919 No. 7

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MEMBERSHIP AND DUTIES OF COMMITTEES OF THE SOCIETY.

1. **Executive Committee:** John F. Hayford, W. O. Wiley and F. L. Bishop.
2. **Publication Committee:** John F. Hayford, W. O. Wiley and F. L. Bishop.
3. **Program Committee:** John F. Hayford, John T. Faig, E. R. Maurer, W. O. Wiley and F. L. Bishop.

Committees Nos. 1, 2 and 3 have their work defined by the By-Laws of the Society.

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5. **Joint Committee on Engineering Education:** Representatives from the several organizations. Desmond FitzGerald, *Chairman.*

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American Institute of Chemical Engineers: J. W. Withrow.

American Chemical Society: C. R. Richardson and H. P. Talbot.

American Institute of Mining Engineers: H. M. Howe and J. H. Hammond.

Carnegie Foundation for the Advancement of Teaching: H. S. Pritchett and C. R. Mann.

7. **Institutional Committee:** John T. Faig, *Chairman,* C. S. Howe, Wm. Easby, F. W. Sperr, G. C. Anthony, T. U. Taylor and H. W. Tyler.

To formulate one or more catalog descriptions of courses of instruction as illustrations of what should be done.

8. **Committee on Admission:** E. P. Coddington, *Chairman,* H. L. Kent and H. E. Webb.

Study of the methods of admission to engineering schools, including European schools.

9. **Committee on Administration:** E. R. Maurer, *Chairman,* L. M. Hoskins, J. C. Nagle, H. S. Evans, W. M. Thornton, Ira N. Hollis and D. S. Kimball.

10. **Committee on Mathematics:** L. C. Plant, *Chairman,* E. R. Hedrick and C. E. Comstock.

Coöperate with the Mathematical Association of America.

11A. **Committee on Physics:** G. W. Stewart, *Chairman,* F. K. Richtmyer, Barry MacNutt, C. F. Burgess and H. H. Higbie.

Study of the first course in Physics.

11B. **Joint Committee on Chemistry:** R. M. Bird, *Chairman.*

American Chemical Society: H. P. Talbot, S. W. Parr and R. H. McKee.

Society for the Promotion of Engineering Education: R. M. Bird, J. H. James and J. R. Withrow.

12. **Committee on English:** C. W. Park, *Chairman,* J. R. Nelson, Sada A. Harbarger and Frank Aydelotte.

    Continue the study of the present status of the teaching of English to engineering students.

13. **Committee on Mechanics and Hydraulics:** O. H. Basquin, *Chairman,* J. E. Boyd, C. H. Burnside, H. F. Moore and C. I. Corp.

    The main objectives in teaching these subjects.

14. **Committee on Economics:** C. C. Williams, *Chairman,* A. B. McDaniel, G. F. Swain, W. G. Raymond and E. B. Paine.

    Work defined by the Committee.

15. **Committee on Civil Engineering:** A. H. Fuller, *Chairman,* W. C. Huntington, H. J. Burt, C. T. Morris and J. Hammond Smith.

    Methods and details of teaching structural design.

16. **Committee on Mechanical Engineering:** O. A. Leutwiler, *Chairman,* T. E. French, W. T. Magruder, J. R. Allen and H. Wade Hibbard.

    Methods of teaching machine design.

17. **Committee on Electrical Engineering:** C. F. Harding, *Chairman,* O. J. Ferguson, Alexander Gray, H. E. Dyche and F. T. Dargan.

    A study of the present practice in regard to the teaching of direct currents and alternating currents versus the teaching of electrical currents.

18. **Committee on Mining Engineering:** F. W. Sperr, *Chairman,* E. A. Holbrook, J. B. Porter, H. H. Stoek and F. A. Thomson.

    Continue present investigations.

20. **Committee on the Standardization of Technical Nomenclature:** John T. Faig, *Chairman,* W. D. Enins, F. N. Raymond, Chas. Warren Hunt and S. E. Moss.

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    To be called upon if an emergency arises.

Special Committee: W. E. Mott, *Chairman,* Chas. S. Howe, L. M. Hoskins, T. U. Taylor and F. H. Constant.

To study the report of the Joint Committee on Engineering Education and report to the Society.

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Henderson, W. E., Professor of Chemistry, The Ohio State University, Columbus, Ohio	1919
Hinsch, Van Buren, Instructor in Mathematics, Missouri School of Mines and Metallurgy, Rolla, Mo.	1919
Hoelscher, Randolph P., Instructor in Civil Engineering, University of Illinois, Urbana, Ill.	1919
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Kazdan, Charles B., Head Instructor, Graduate Student Course, Central Station Institute, Commonwealth Edison Company, Chicago, Ill.	1918
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WING, FRANCIS H., Supervisor of Industrial Education, Buffalo Public Schools, Buffalo, N. Y. 1919

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WALDO, W. G., President, Southern Cottrell Precipitation Co., Chattanooga, Tenn.

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WEAVER, WARREN, 17 W. Gilman St., Madison, Wis.

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WICKENDEN, WILLIAM E., Personnel Manager, Engineering Dept., Western Electric Co., 463 West St., New York, N. Y.

Wills, Charles F., Consulting Supervisor, Dept. of Industrial Relations, Phelps Dodge Corp., Drawer G, Bisbee, Ariz.

Winslow, A. M., Dept. of Mechanical Engineering, University of Washington, Seattle, Wash.

Witham, R. L., Assistant Engineer, Sperry Gryroscope Co., Manhattan Bridge Plaza, Brooklyn (8578 111th St., Richmond Hill), N. Y.

Wittig, G. F., Assistant Professor Sloane Laboratory, Yale University, New Haven, Conn.

Wohlenberg, W. J., Assitant Professor of Mechanical Engineering Sheffield Scientific School, Yale University, New Haven, Conn.

Wolfe, W. S., Structural Engineer, Hull Scientific Branch, Division of Steel Ship Construction, Emergency Fleet Corp., 140 North Broad St., Philadelphia, Pa.

Wright, C. A., Professor of Electrical Engineering, The Ohio State University, Columbus, Ohio.

Young, L. E., Room 400, Union Electric Building, St. Louis, Mo.

NAMES TO BE REMOVED FROM YEAR BOOK DUE TO DEATHS AND RESIGNATIONS.

Ayres, Brown
Baebenroth, A. C.
Bailey, A. R.
Bankson, E. E.
Bell, J. M.
Bellis, A. E.
Betts, Philander
Biegler, P. S.
Bratton, W. A.
Bush, Vannevar
Cajori, Florian
Christian, J. W.
Dean, Stanley
Dennison, B. C.
Duff, C. M.
Edwards, W. W.
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Fisher, Geo. H.
Frankforter, G. B.
Garver, J. D.
Gates, A. O.
Gearhart, W. S.
George, R. D.
Groetzinger, Carl A.
Hastings, H. B.
Henley, W. W.
Henshall, P. P.
Herschel, W. H.
Hooper, W. L.
Hund, August
Jackson, John Price
Jones, G. R.
Kent, William
Knapp, W. A.
McAlister, E. H.
McLeod, D. F.
McNair, G. B.
Marburg, Edgar
Mason, A. J.
Miser, W. L.
Moore, F. C.
Moritz, R. E.
Oglesby, N. E.
Parmelee, H. C.
Pope, Willard
Randall, O. E.
Richardson, Clifford
Ridout, John
Rodgers, L. J.
Root, J. E.
Russell, L. K.
Sawyer, A. R.
Schildhauer, Edward
Smith, R. J.
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Sweetser, E. O.
Taylor, I. I.
Touceda, E. A.
Trummell, M. F.
von Ende, C. L.
Warner, F. M.
Wheatley, G. S.
Wurts, A. J.

DECEASED MEMBERS.

Name.	Year of Election.	Date of Death.
Ayres, Brown	1898	
Christian, J. W.	1914	February 24, 1918.
Dean, Stanley	1917	October, 1918.
Garver, J. D.	1915	February 11, 1919.
Hooper, W. L.	1907	October 3, 1918.
Jones, G. R.	1914	December 22, 1918.
Kent, William	1894	November 1, 1918.
Marburg, Edgar	1894	June 27, 1918.
Parmelee, H. C.	1916	
Stevens, J. Floyd	1913	October, 1918.
Trummell, M. F.	1915	August 4, 1918.

BOOK REVIEW.

Sound, Light, Electricity and Magnetism. By William Ballantyne Anderson, Ph.D., Professor of Physics, Oregon State College. First edition. xiii + 337–794 pages. McGraw-Hill Book Company, Inc., 1919. Price, $2.00 net.

The present volume is the latter part of a complete text book, the Mechanics and Heat part of which has already been published. The two books will be combined thus giving a complete text in one volume.

The author has presented his subject in an interesting way, yet in such a manner that all the underlying principles of this great subject are clearly brought out. The student is lead from the simple easily understood portions of the subject by short intellectual steps to the more involved relations, accompanied on his way by the mathematical deductions and relations, so that at the end of his journey he has a complete conception of physics.

The book is modern in every respect, the chapters on Radioactivity and Radiotelegraphy containing much matter that has not heretofore appeared in books of this nature.

In the reviewer's opinion this book will prove very acceptable to those who are looking for a clear, direct, and quantitative method of teaching physics. G. I. M.

COLLEGE NOTES.

Kansas State Agricultural College.—Dr. William Marion Jardine was inaugurated into the presidency of the Kansas State Agricultural College, Manhattan, Kans., on Tuesday, February 4.

In his inaugural address Dr. Jardine laid down a program embodying a combination of industrial and liberal training as the most important step in future education. He urged the adoption of world-wide principles of education as a preventive of wars and suggested an educational commission of advice in any league of nations that should be established.

Dr. Raymond Allen Pearson, president of the Iowa State College, who was the principal speaker from outside the state, emphasized the importance of moral, and physical, as well as intellectual training. He traced the history of agricultural and industrial education from its beginnings in the United States to the present time. He characterized as inspired the passage of the Morrill Act, which established land-grant colleges in the various states.

Dr. Jardine, the new president of the Kansas State Agricultural College, was born on a ranch in Idaho in 1879. He holds the degree of bachelor of science in agriculture from the Utah Agricultural College and of doctor of laws from Campbell College. He has been a member of the faculty of the Kansas State Agricultural College since 1910, when he came to the institution as professor of agronomy. Prior to his election to the presidency he had served for several years as dean of agriculture and director of the agricultural experiment station.

He is a former president of the American Society of Agronomy, of the International Farm Congress, and of other organizations. He is one of the best known authorities on dry farming, having been at one time specialist in this subject for the United States Department of Agriculture, and being author of many bulletins and special articles on this subject, published in the United States and in foreign countries.

Lafayette College.—Signal recognition of the work of Dr. Edward Hart, professor of chemistry at Lafayette College for the past forty years, has been paid in the establishment recently in his honor at Lafayette of a $10,000 fellowship, to be known as the Edward Hart Fellowship in Chemistry. This fellowship, yielding $500 a year, is open to all students of chemistry holding the bachelor's degree, and, at the suggestion of the National Research Council, the holder is to do research work in problems connected with viscous and plastic flow—practically a virgin field, and of vast importance to industry and pure science. The recipient of the fellowship is expected to spend the academic year in residence, and the work done may be counted towards meeting the requirements of a graduate degree.

The project of the fellowship was conceived about a year ago at a dinner of the New York City alumni association. The fund has now been completed through the generosity of a comparatively small group of Lafayette men. The committee under whose auspices the fellowship was endowed consists of George P. Adamson, chairman, George Auchy, Gideon Boericke, Hugh E. Meyers, Matthew Scammel, Gustave Wiedenmayer and Eugene C. Bingham, secretary.

Professor Hart, whose services have been thus splendidly recognized, is widely known for his services to the science of chemistry. He is the inventor of some notable chemical and industrial apparatuses, a widely known writer of chemical text-books and editor of chemical journals, a publisher of chemical books, a manufacturer of pure chemicals, an investigator of practical chemical problems, an excellent teacher and a public-spirited citizen. The men whose generosity has made the fellowship possible are practically all former students of Professor Hart, who contribute in a large measure their achievements in life to his instruction and inspiration.

ARMY VOCATIONAL TRAINING.

BY C. R. DOOLEY,

Educational Director.

The Committee on Education and Special Training was appointed in February, 1918. Early in the spring plans were developed to train 90,000 men for the service who would meet certain definite specifications. These specifications were: first, that the men must be soldiers, disciplined to prompt and complete obedience and accustomed to the routine of army life; second, these men must be skilled in some trade specifically needed in the army; third, these men must have that originality and initiative which would prompt them as soldiers to use the tools and materials at hand in meeting emergencies. In other words, the problem was not one of

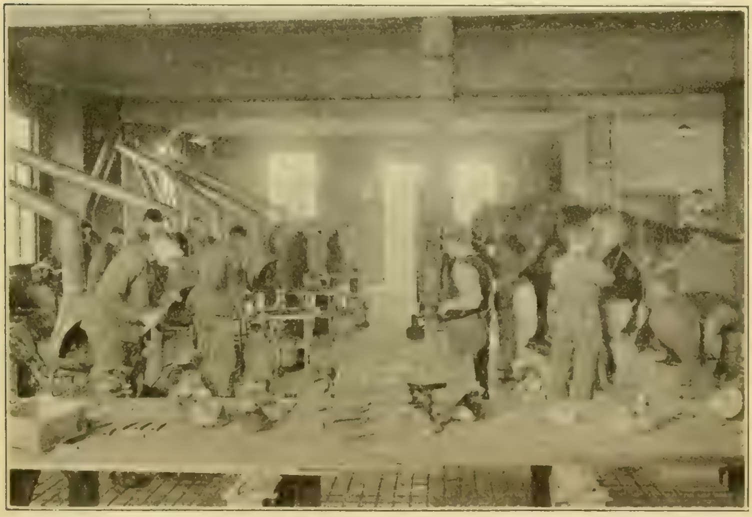


FIG. 1. A Class in Horseshoeing, Cornell Detachment.

turning out an aggregation of mechanics but rather an organization of soldiers possessing special trade ability.

The length of the course decided upon for this experiment was two months, and it was proposed to train the 90,000 men between the fifteenth of April and the fifteenth of November. I use the word "experiment" advisedly for the job was absolutely new and no one was in position to prophesy to what degree it would succeed.

A plan of organization was adopted which would largely decentralize inspection and administration. The committee, the advisory board, the executive military officers and the vocational director remained in Washington in charge of the planning. At first the United States was divided into ten districts, each with its field military officer and district vocational director in full charge of administrative details. Later the districts were increased to twelve and a central office for

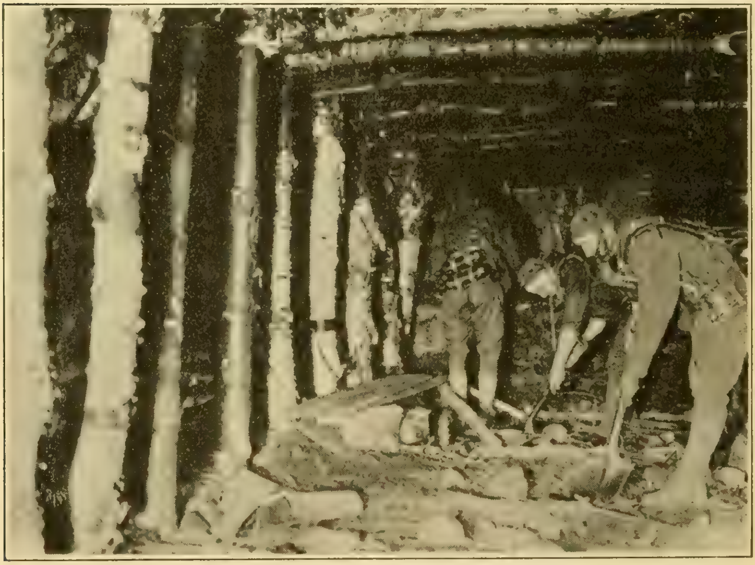


Fig. 2.

each district was established as a headquarters for the field military officers, district vocational directors and the field representatives in charge of business relations. Through this plan of organization, responsible administrative officers were constantly traveling in all sections of the country approving, establishing and inspecting units. The results of the work of the field organization were wired to Washington each night, and the field organization was kept informed by telegraph of the changing needs as to numbers of men required in each trade and changes in specifications of the soldiers duties in the various trades taught.

Possibly some explanation is required of the fact that as the war progressed the type of men required in many of the trades changed as well as the number of men in each trade. This was partly due to the circumstance that the committee was called upon to supply men whom the army could not get through the draft boards and partly due to the continual

FIG. 3.

change in the character of the available supply of men obtainable from the Provost Marshal General's office. Changes in equipment and plans of organization of army corps and changes in methods of warfare were constantly producing changes in the trade specifications. It was found necessary in the summer to establish a subdivision of the organization at Washington with representatives from each of the corps charged with the special duty of keeping the committee informed of the requirements in numbers and the changes in specifications in the various trades.

FIG. 4.

The daily program in each of the schools was alike in that it had three hours a day of military training and six hours a day of trade instruction. The military instruction included infantry drill, military courtesy, inspection and general military subjects, tending not only to break in green men but to develop habits of promptness, decision and order and to establish a company spirit in place of the normal American individual spirit.

To a remarkable degree, the military team work spirit, the discipline, and courtesy influenced the atmosphere of the shops and class rooms and greatly strengthened the vocational interest of the soldiers. So great was this influence in fact that I doubt if satisfactory vocational work could have been done without the accompanying military training. Each man seemed eager to find the place in the war team to which he was to be assigned and eagerly sought to train himself to play the game according to the rules. The enthusiastic leadership of the military officers contributed greatly to this war spirit.

FIG. 5.

As a preliminary to the trade training an attempt was made to sort the men and assign them with due regard to their experience and natural aptitude. When it was possible to assign a man to a trade in which he had experience and for which he had natural aptitude, the job of training him was easy. If a man has made a success at a given line of work the chances are favorable for giving him further special training along the same lines. On the other hand, the circumstances of youth have often prevented men from following their natural talents. When experience and natural aptitude are opposed, the best of judgment and tact was required to determine the right classification and assignment. Such cases were by no means the exception for there were assigned for training occasional details which contained not a single man with experience in any of the trades to be taught, and what was still more discouraging in the early days to the supervisors, the details contained few men with any apparent natural aptitude for any of the trades.

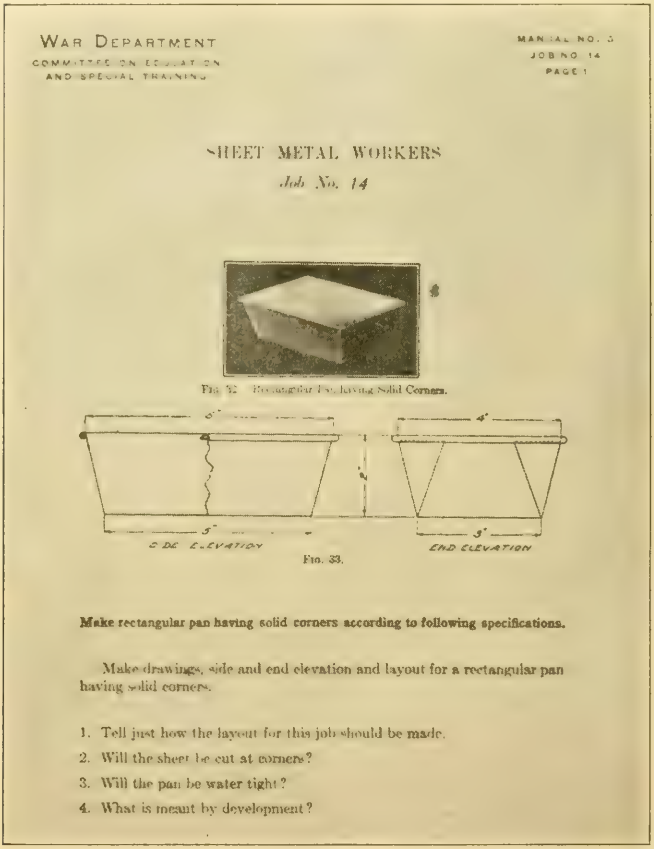
I well remember a long distance telephone call from one of our schools, during which the supervisor with tears in his voice reported that he had just received 400 men to train as blacksmiths, carpenters, electrical workers and machinists, who were classified as to experience as laborers, garment workers, teamsters and 'longshoremen, but who in the private opinion of the supervisor, were chiefly loafers, toughs and ne'er-do-wells. Certainly this detail was made up of men who had never been in an industrial shop and had never handled a shop tool or a foot rule. The prospect for their successful training seemed hopeless to the supervisor.

After some persuasion this supervisor assigned his motley group to classes and started the job. It was only a few days before signs of a remarkable change began to appear in these men. With the aid of an able commanding officer and his lieutenants, admirable military discipline was quickly brought to the aid of efficient shop instruction with the result that 360 "fighting mechanics" were delivered to the army on schedule.

Of this number, 26 were blacksmiths and not one had ever struck a piece of iron while it was hot previous to joining the school. So enthusiastic were the instructors over their accomplishment with these men that at the end of six weeks, they reported them as having made greater progress than the regular students in a year's time. You may be sure that we were proud of these men; you may be sure that their teachers, and in fact, the whole organization, were proud of these men when they left at the end of their eight weeks training. The men took pride in their ability to do a real job and they took satisfaction in the training which made them feel that they belonged to the military organization. One must live through an experience of this kind in order to realize the remarkable, may I say almost miraculous, change that was brought about in these men through combined military and vocational training.

I am not sure that I have made sufficiently prominent one of the essential facts in my last illustration. Not merely did we undertake to train all of these ill-assorted men, but practically a hundred per cent. of them were turned out as soldiers with some useful special aptitudes. Contrary to civilian practice, there was no thought of weeding out the less skillful, but instead each man was trained to do something which would make him useful to the army organization.

If you were to ask one of the supervisors of the 155 schools that coöperated in this vocational training, they would multiply instances indefinitely of men without previous background of experience, learning within the prescribed eight weeks to turn out a finished commercial job in some one of the 71 trades. Dean Bishop likes to tell of a farmer boy who reported to the University of Pittsburgh with but a common school education. He was assigned to the sheet metal shop and within six weeks he was turning out stove pipe elbows, baking pans, mess tins, and a variety of other commercial articles from patterns which the soldier himself developed by sound principles of descriptive geometry. He had been required to make a drawing and a stretchout pattern for each job which he undertook and through this, the principles of projection and intersection were learned in a manner which made them available for practical application; learned in this way these principles became something more than memorized facts. There is something inspiring about the method and atmosphere of this work which gripped this man and



WAR DEPARTMENT
COMMITTEE ON EDUCATION
AND SPECIAL TRAINING

MANUAL NO. 3
JOB NO. 14
PAGE 1

SHEET METAL WORKERS

Job No. 14

Fig. 32. Rectangular Pan having Solid Corners.

6"
5"
SIDE ELEVATION
4"
3"
END ELEVATION

Fig. 33.

Make rectangular pan having solid corners according to following specifications.

Make drawings, side and end elevation and layout for a rectangular pan having solid corners.

1. Tell just how the layout for this job should be made.
2. Will the sheet be cut at corners?
3. Will the pan be water tight?
4. What is meant by development?

Fig. 6.

hundreds of others like him and gave them all an enthusiasm for some form of industrial work which promises to survive the war. Three men in the pattern-making course at the Carnegie Institute of Technology, who had formerly been bank clerks, are reported by Dean Connelly to declare most emphatically that they will never leave the wood-working industry.

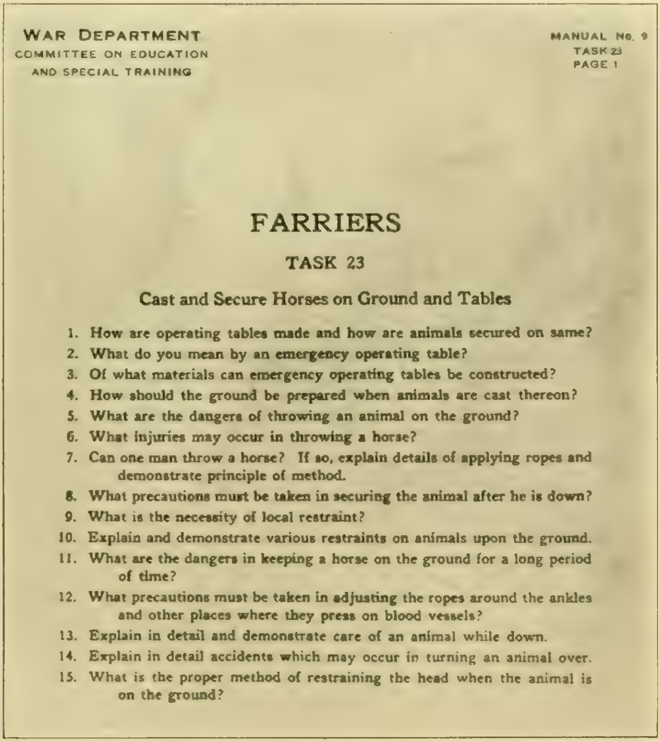
The method of instruction which was adopted by all of our schools can best briefly be described by saying that the men *learned by doing.* If you will notice the first slide, you will see that a class of men in Cornell are learning to shoe horses; they are making the shoes and they have the horses at hand. In the right-hand corner, you will see a husky looking private putting the shoes where they belong. In slide 2, we have a picture of the miners at the Michigan School of Mines learning the game by working underground under the direction of an experienced mine boss. The men in this school were divided into two platoons, which alternated daily in taking instruction in underground work and in above ground instruction in military subjects and in classroom discussion of mine practice. Slide 3 shows telephone linemen splicing a cable under field conditions in Idaho. Slide 4 shows the soldiers of the training unit at Mooseheart putting in a section of concrete road. Slide 5 shows one of the devices used in testing truck drivers as to the accuracy with which they handled a vehicle. The problem here was to drive between flags without knocking any down.

This method of learning by doing seems to harmonize with something that is fundamental in human nature. The creative instinct seems to be a more common possession of mankind than is generally supposed. Certainly the accomplishment of practical results without help is one of the most stimulating of human experiences. With this creative instinct aroused, a man normally becomes hungry for more accurate and deeper scientific information in order that his creation may be more perfect. He thereafter begins to teach himself and the instructor gradually finds himself functioning as a means of the final checking of results.

In order to facilitate the teaching of soldiers by doing practical jobs, the division of our Washington organization, responsible for methods of instruction undertook to develop a series of manuals which suggested a course of instruction for each trade. Each course was made up of jobs graduated in difficulty and progressively calling for additional trade knowledge and skill. Slide 6 illustrates a sheet metal job sheet. You will notice that this starts out with a brief command as to the article to be made. It shows a photograph and a sketch of this article and directs that a drawing and layout be made in advance of undertaking the actual construction of the article. These directions are followed by questions, the first of which are designed to aid the men to think through the essential steps in performing the task. The

FIG. 7.

later questions are intended to insure that he accumulates all the information and knowledge of principles which should properly be associated with doing the particular task. The men are expected to find out the answers to these questions during the process of doing the job. The instructor is not so much a source of information as a court of last appeal, who can settle discussions, rectify mistakes and prevent delays through indecision. One of my associates illustrates the philosophy of this method from poultry lore by saying that it is better to feed scratch food than whole corn. Whether or not



WAR DEPARTMENT
COMMITTEE ON EDUCATION
AND SPECIAL TRAINING

MANUAL No. 9
TASK 23
PAGE 1

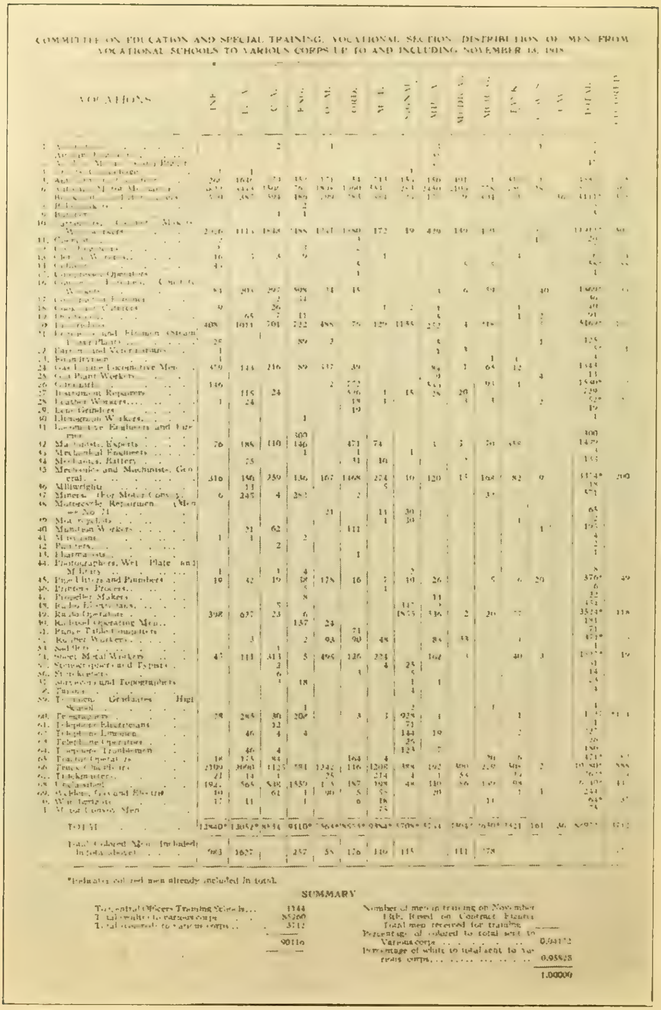
FARRIERS

TASK 23

Cast and Secure Horses on Ground and Tables

1. How are operating tables made and how are animals secured on same?
2. What do you mean by an emergency operating table?
3. Of what materials can emergency operating tables be constructed?
4. How should the ground be prepared when animals are cast thereon?
5. What are the dangers of throwing an animal on the ground?
6. What injuries may occur in throwing a horse?
7. Can one man throw a horse? If so, explain details of applying ropes and demonstrate principle of method.
8. What precautions must be taken in securing the animal after he is down?
9. What is the necessity of local restraint?
10. Explain and demonstrate various restraints on animals upon the ground.
11. What are the dangers in keeping a horse on the ground for a long period of time?
12. What precautions must be taken in adjusting the ropes around the ankles and other places where they press on blood vessels?
13. Explain in detail and demonstrate care of an animal while down.
14. Explain in detail accidents which may occur in turning an animal over.
15. What is the proper method of restraining the head when the animal is on the ground?

FIG. 8.



COMMITTEE ON EDUCATION AND SPECIAL TRAINING. VOCATIONAL SECTION. DISTRIBUTION OF MEN FROM VOCATIONAL SCHOOLS TO VARIOUS CORPS UP TO AND INCLUDING NOVEMBER 13, 1918

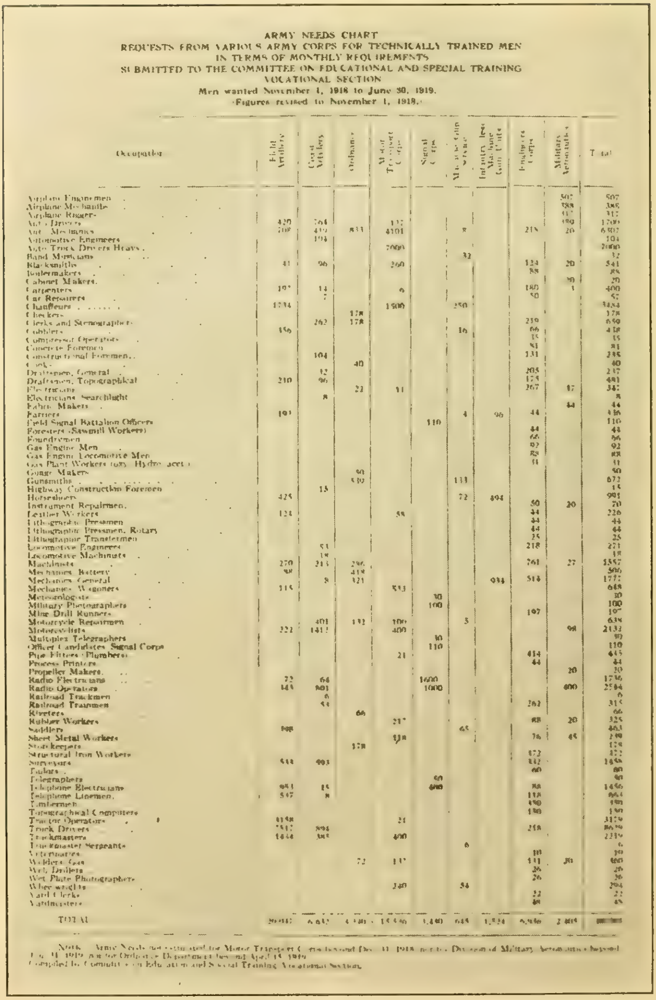
FIG. 9.

the illustration is good, it is certainly much better that the instructor should judge the correctness of the information which the men have obtained by their own efforts than that he give them the information.

This plan of teaching men by doing worked out well in a great variety of trades. Slide 7 shows some farriers in training. By the way, when we were asked to train farriers, we all added a new word to our vocabulary. After many wrong guesses on our part, our military advisors informed us that "A farrier is an animal nurse." He does not diagnose disease and prescribe for it, but treats and generally cares for sick animals, under the direction of a veterinarian. The soldiers in this class had prepared an operating table of corn husks. They had so fastened restraints upon "Mr. Mule" that at the signal, he suddenly found himself stretched out on the operating table. These fellows are having the time of their life making "Mr. Mule" do what he evidently does not enjoy. Slide 8 shows the corresponding job sheet with the questions which bring out the high spots in the problem of throwing animals.

Slide 9 gives the statistics of the number of men trained and delivered to the various army corps up to November 13. This slide also emphasizes the variety of trades for which the men were trained and the diversified demand for the product of our schools in the various corps. Slide 10 illustrates the diversity of the demand by giving the army needs in terms of the monthly requirements in each trade as reported to the committee on November first. It will be noticed that the army needs for the product of the committee schools had reached a demand for 60,000 men a month and the total requests for trained men to be delivered by the committee up to July 1, 1919, had reached the total figure of 760,000 men.

Mere numbers of course do not tell the whole story. Yet there is one fact about the numbers trained in our vocational schools which meant a great deal to our military program. The soldiers in training in our schools represented numbers



ARMY NEEDS CHART
REQUESTS FROM VARIOUS ARMY CORPS FOR TECHNICALLY TRAINED MEN
IN TERMS OF MONTHLY REQUIREMENTS
SUBMITTED TO THE COMMITTEE ON EDUCATIONAL AND SPECIAL TRAINING
VOCATIONAL SECTION
Men wanted November 1, 1918 to June 30, 1919.
(Figures revised to November 1, 1918.)

FIG. 10.

under arms in excess of the capacity of the cantonments. It in this way came about that, as a result of our training program, 70,000 trained soldier mechanics were sent to France in excess of the number which could have otherwise been sent.

I have come here today to submit to you the question as to whether there may not be a lesson in this army experiment to guide us in the reconstruction vocational education program which this country must not fail to undertake. I do not know what machinery will be set up to bring together groups of men with strong vocational motives for post-war training. Certainly, even with military instruction, it would be difficult to exactly reproduce the war spirit which animated our "fighting mechanics." Nevertheless, I cannot escape the conviction that whatever limiting conditions may surround vocational instruction in this country in the future there will still be something of value to be learned from the success of these two months vocational courses. For those who would study the record of this experiment further, there will presently be available a final report and a limited supply of copies of the instruction material.

SOME UNCONSIDERED FACTORS.

BY S. A. HARBARGER,

New York, N. Y.

The most important considerations which enter into any discussion of the teaching of English literature and composition to students in engineering colleges are three: (1) The professional training of the instructor in his subject; (2) the personality of the instructor; (3) the coöperation of the engineering college.

That the instructor should be well versed in his subject seems self-evident. Some comment in passing, however, is apropos, since his use and interpretation of his professional knowledge are significant. Indeed, upon his adaptation of his specialized information to the peculiar needs of his students depends his success. That is, he must acknowledge that there are other things of real value in the world beside English which can hold and stimulate the minds of eager, thoughtful persons to high endeavor. He is tolerant and sympathetic, therefore, toward the attitude of the general reader. He never loses sight of the place that literature and writing must always occupy in the mind of every one who has not made the study of them a profession—as a means of expressing an absorbing idea; as a means of escape when the serious business of life becomes intolerable and routine threatens to madden; as recreation. To meet these needs of the layman reader, the English instructor adapts his choicest wares in expression and thought.

Next, he who would teach English to the engineering student must be a person with broad sympathies, and a keen understanding of the characteristics of this particular type of student. To the casual observer the engineer is generally no more than an earth-bound being whose spirit is easily stirred only by the most crass materialism. No one will deny that he is practical; that he demands tangible results from every project upon which he expends his thought and energy; that he is shrewd; that he is definite. Yet he has also some characteristics to which English literature and composition may make a powerful appeal and which may be utilized by the English instructor.

First of all, he has an eagerness, an enthusiasm for his own profession which may easily be made to include more than its most apparent and narrowly technical phases. Second, he has imagination and idealism. He is always dreaming of his Golden Age, though he knows of no way but the materialistic one whereby it may be realized. Tactfully guided, he is willing, however, to hear and to think over the dreams and visions of the great writers. In other words, if the teacher of English understands; if he has lived and experienced life within and without academic circles; if he centers his English teaching around the engineer's burning interests and leads out from them, he can stimulate the highest appreciation of the best that is thought and said in the world, in the mind of this practical student.

Again, to teach engineers successfully the English instructor should come to his work with some innate interest in engineering. This statement does not mean that the instructor must have at his tongue's end all the scientific nomenclature of the engineering profession or be able to speak authoritatively upon all its intricacies. It simply means that he must take sincere enjoyment in the broad aspects of the various projects in which the engineer takes delight and upon which he lavishes his attention. As a result of this inherent interest, the instructor will use naturally and easily illustrations and comparisons which he knows will be intelligible and vivid to his particular students. This means, supplemented by a personal knowledge of what each individual student gives most thought to, indicates to the engineering student that the English teacher's interest is genuine. A college course in engineering is not necessary to furnish the instructor with general technical information. Indeed it is preferable that he should not have a specialized course, though a knowledge of higher mathematics,, of physics, and of chemistry is not to be despised. Yet if he has only a general knowledge of the sciences and a broad view of the technical course, he runs less danger of making a humanistic subject too highly specialized and too technical in its leaning—a fault which frequently arises from intensive technical training and the concomitant narrowing of range. For the effective teaching of a humanistic subject such as English, the medium of intercourse grows out of the technical interest of the students; the result, however, does not curtail, but broadens the general interests. Consequently, the final attitude of the student depends upon the personality of the instructor—his balance, his enthusiasm, his acquaintance with various phases of life and types of men, and his insight into the mind of the individual—far more than upon his knowledge of engineering.

Yet possessed of all these qualities, unaided, the English instructor can not hope to secure the best results. He must have the good-will, the sanction and the open coöperation of the faculty of the college of engineering. One has only to recall one or two of the characteristics of the engineer previously noted—his shrewdness, his practicability—to recognize and appreciate the aid that comes from hearty coöperation on the part of the engineering faculty. For, if the members of his own corps of instruction point out the value of such a subject as English, which appears to be totally unrelated to an undergraduate course in engineering; if the instructors of strictly technical subjects cite cases in which the possession or lack of English has had a far-reaching effect upon the outcome of some technical problems; if they manifest a pleasure in the best of the world's thought; and if they insist upon intelligible and accurate expression of ideas, they carry conviction, break down a barrier and drive home the teaching of the rhetoric instructor, who even under the most favorable circumstances, is regarded as a somewhat prejudiced witness. The most successful teaching of English to engineering students, therefore, must always include as a part of its method the coöperation of the engineering faculty.

BACHELORS OF SCIENCE OR SKILL?

BY W. H. RAYNER,

Associate in Civil Engineering, University of Illinois.

There is good reason to believe that our schools of science and technology may well consider whether or not they are quite sincere or accurate in the labels they put on their product. On commencement day the graduate has conferred upon him a bachelor degree in some branch of engineering or of science; but if we look carefully into the training he has received there may be some question regarding his possession of the essential attributes of the engineer or scientist. A brief consideration of some of the implications involved here may be of some interest.

The word ''engineer'' from its very meaning of course refers to one possessed of such qualities as ingenuity, inventiveness, etc.; while the attributes of the scientist are also quite definite even though they cover a broader range of human activity. The scientific method in which both the engineer and scientist are supposed to be trained is quite a definite procedure and has been stated by John Dewey* as follows:

''In any given science we attempt to state our knowledge in such form that it will answer both of these requirements, so that we may test any given proposition by noting whether and how it follows from other propositions taken as established and also may utilize given propositions to arrive at others not previously known. The process of obtaining data (or evidence), of definition (or fixation of meaning), of generalization (or reduction to principles), and of classifications

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* Monroe, ''Educational Encyclopedia,'' under Scientific Method.

(or graded grouping) characteristic of any science, are the means taken to satisfy these requirements.''

He then goes on to make the following significant comment: ''What is taught as science is often nothing more than a peculiar or technical body of information (*q.v.*). Externally speaking, it is science. That is, at some time it was actually reached by processes of reflective inquiry conforming to the general canons just mentioned. Moreover, it is labeled science in the educational scheme. But in so far as the pupil is unaware of the processes of reflective thought which give the information its characteristic scientific status, it has no real right to the title of science, and in so far as he does not himself go through these processes and thereby take an active part in performing the specific logical processes that transform the body of facts and laws into a science, there is no genuine study of *science.* There is merely the acquisition of a certain bulk of externally communicated information, information which is, indeed, distinctive in its technical terminology, but which is for that very reason more remote from any actual thinking on his own part than acquired information of a more familiar sort.''

In the light of these statements, let us look at our collegiate methods in science instruction. The usual method of procedure in many courses in science is made up of the following parts: (1) Assignments from a text; (2) references for collateral reading; (3) lectures; (4) laboratory practice; and (5) examinations, daily, weekly or term.

The function of each of these parts may be briefly characterized as follows: (1) The text gives in convenient form the main facts and principles to be covered; it describes the achievements of other men—often most ingenious and stimulating achievements but very little is said of the painstaking, patient, systematic procedure and resourcefulness contributing to the attainment of the results secured; (2) the collateral reading supplements the text; (3) the lectures may be of two types; (*a*) demonstration lectures, where an experiment is performed before the class to illustrate some principle, or (*b*) outline lectures, where an organized body of facts is given to the class, which serves to amplify the students' reading and to give coherence to the course; (4) laboratory practice consists largely in using apparatus assigned, following specific directions from a laboratory manual to secure prescribed results, and usually followed by a written record and interpretation of the results achieved; (5) the examinations are used to test the students' comprehension of the facts and principles he is supposed to have mastered.

In its relation to the educative process, it is noted that this procedure gives excellent training in the ability to follow directions; to record and exhibit results neatly and concisely; it provides the student in a very efficient manner with a large body of facts and data; and it develops the students' powers of observation and deduction. It is, however, quite devoid of opportunity for training in the scientific method. There is little resourcefulness or initiative required in any of the steps mentioned above. The whole performance is carefully planned *for* the student, not *by* the student. He manipulates objects but does not devise methods, he learns many facts but discovers none by his own research.

The distinction is not a new one. There is no claim for novelty in this regard. Rousseau in speaking on this principle in Emile's education said: "Let him not learn science, let him invent it" (Emile, iii, 173). "Emile will never know optics. He will never have dissected insects; he will not have counted spots on the sun; he will know neither microscope nor telescope. Your learned pupils will deride him. They will not be far wrong; because before using these instruments I mean that he shall invent them, and you are right in believing that this will not be early" (Emile iii, 223).*

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* Cited by J. P. Monroe, "The Educational Ideal," Boston, 1896, p. 166.

I suppose none would regard this as practicable procedure; each generation must not be given the task of reinventing all that has preceded, and yet there is in this proposal the germ of true education in science. This method would provide opportunity for the expression of the creative impulses in the individual which constitute the very breath of life to the scientist. This point receives support from Professor Henry Fairfield Osborn, in whose book on ''Huxley and Education'' we find on page 9 this sentence: ''The lesson of Huxley's life and the result of my own experience is that productive thinking is the chief *means* as well as the chief *end* of education, and the natural evolution of education will be to develop this kind of thinking earlier and earlier in the life of the student.''

It may be that the ''project'' method of instruction, which is spreading so rapidly at the present time, is in part a fulfillment of Professor Osborn's' prophecy. Prof. W. L. Upson, of Union College, who cites the above quotation, believes that we need a new conception in the matter of education in the sciences. In his courses in electrical engineering he endeavors to center his instruction about the laboratory rather than the classroom and encourages the students to ''invent'' as well as to ''learn'' new principles. He thinks that a little original work on the part of the student is worth much more than a few routine reports.*

So it may be that we are training artisans more than we are educating scientists and our degrees might better be given as bachelor of craftsmanship or bachelor of skill. It may be that our educational methods, born of necessity in handling large numbers of students, are wise and justifiable but there should be no delusions regarding the character of the results achieved. It may be good social policy and wisdom in economy of time in our schools to train a large number of persons who can do the routine assistance required in the professions rather than to attempt the more precarious and expensive process of educating scientists. If so, then our present methods may be deemed passably satisfactory. On the other hand, if the purpose of our scientific schools is taken to include the education of true investigators and scientists who are to do their part in broadening our fields of knowledge then, if the above remarks have any significance, they imply the need of a very different educative process.

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* See ENGINEERING EDUCATION, 8, 5, p. 192.

Positions Wanted

951. CAPTAIN OF ENGINEERS with seventeen years' experience, seven of these as head of electrical engineering department, is open for fall engagement, west preferred.

952. ELECTRICAL AND MECHANICAL ENGINEER, now assistant professor of electrical engineering at prominent Eastern university, desires connection with Mid-Western engineering school. Capable of taking entire charge of electrical or mechanical engineering department.

953. INSTRUCTOR IN MECHANICAL ENGINEERING, seven years State University, lectures, laboratory, research, desires advancement. Degrees, energetic, competent, practical experience. Aërodynamics and wind tunnel work. Personal interview at S.P.E.E. annual meeting, The Johns Hopkins University, Baltimore, Md., if prospects good.

954. A NAVAL ARCHITECT AND ENGINEER with three years' teaching experience in steam engineering and six years of practical work in engineering and ship design, would like to obtain a professorship in naval architecture or some branch of steam or gas engineering. Have been engaged in war work for the past four years and now desire to return to teaching. Graduate of the Massachusetts Institute of Technology.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., APRIL, 1919 NO. 8

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ELECTRICAL ENGINEERING AS TAUGHT IN AMERICAN COLLEGES.*

BY ALEXANDER GRAY, M.Sc., Whit.Sch.

Much has been written on the subject of "Engineering Education in America," but it is thought that explicit information on the training of electrical engineers would not be without interest to readers of the London *Electrician.*

The majority of American electrical engineers are university graduates; the draughtsmen, foremen and electricians are trained by the trade schools and the correspondence schools. Evening class work is in its infancy and the standard is low. The college-trained engineer, as a rule, attends the grammar school until about fourteen years of age, then goes to the high school for four years, to the university for four years, and finally has two years of practical training in the shops or with the central station and construction companies. The young engineer is, therefore, about twenty-fours years of age before his training is complete.

The standard of the grammar school and of the high school is somewhat lower than in the British Isles, so that four years are required for the university work. During the first two years the studies are of a general character, and include mathematics, physics, chemistry, English, shop work, mechanics and drawing. During the last two years the student has to specialize in some one branch of engineering, such as civil, electrical, industrial, mechanical, mining or transportation, and the studies are almost entirely of a technical character.

Entrance Requirements.—Each applicant for admission to the engineering school must show that he possesses a good general education, and he can do this either by passing the university entrance examination or by presenting an acceptable school certificate. The list of subjects required for entrance to the four-year course of a high-grade school such as that at Cornell University is

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* Reprinted from *The Electrician,* London, Vol. LXXXI., No. 30.

Mathematics	Four units, including advanced algebra and trigonometry.
English	Three units.
Foreign language	Three units in one language.
History	One unit.
Elective subjects	Four units.

The "unit" is a recognized term used in America to indicate that the student has studied the subject five hours a week for one year; two hours of laboratory parctice are considered the equivalent of one hour of class work. The required 15 entrance units can seldom be obtained by less than four years of high school work.

The success of an engineer depends largely on his ability to meet men of education and culture on equal terms, and since the work of the four-year course is almost wholly technical, it is necessary that the student before entering college should have a thorough general education. Those who have not had this thorough preparation are advised to take a five-year course, so as to spend about one year in the college of arts.

It has already been pointed out that certificates of work done in public or private schools may be accepted in lieu of passing entrance examinations if the university authorities are satisfied with the standing of the school. The records of all students who enter by certificates are closely watched, and when it is found that the graduates of a certain high school are not making satisfactory college records, the principal of that school is notified that he must raise the standard, otherwise the entrance privilege will be denied to his pupils. A high school may thus have a passing grade of 75 per cent., but the principal will not certify that the student can meet the entrance requirements of the larger universities unless he obtains a passing grade of perhaps 85 per cent. Those who cannot obtain this high mark are accepted by universities that have somewhat lower entrance requirements.

The Courses.—There is some variety in the type of instruction offered to electrical engineering students at the different universities. In most cases, however, the work of all engineering students is practically the same for the first two years. A typical course is given below. The entrance requirements for such a course include English, foreign languages and a thorough knowledge of mathematics, including advanced algebra, plane and spherical trigonometry, plane and solid geometry. If this entrance requirement is not met, the course must be expanded into a five-year course.

FOUR-YEAR COURSE IN ELECTRICAL ENGINEERING.

Subjects.	Credit Hours.			
	1st Year.	2d Year.	3d Year.	4th Year.
Mathematics	12	..	..	..
Physics	6	8	..	..
Chemistry	6	5	..	..
Drawing	6	8	..	..
Shop work	3	3	..	..
Surveying	2	..	..	..
General engineering	4	..	..	..
English (engineering reports)	..	2	..	..
Applied mechanics	..	8	..	..
Electrical engineering	..	2	8	22
Materials	..	3	..	..
Machine design	..	..	10	..
Mechanical engineering	..	..	12	4
Hydraulics	..	..	4	..
Business law	..	..	2	..
Industrial organization	..	..	2	..
Economics	..	..	..	4
Electives	..	..	..	8

The unit of one credit hour adopted by most American colleges may mean—

(*a*) One lecture per week for one term of 16 weeks, with the necessary homework problems and class examinations.

(*b*) One recitation on assigned work. This work generally requires two hours of preparation, and the student may be called on in class to work out problems at the blackboard.

(*c*) One computing or drawing period of three hours.

(*d*) One laboratory period of three hours.

(*e*) Three hours required in preparation of laboratory reports.

Eighteen hours of university work, therefore, means 54 hours of actual work per week, and this is about as much as any student should be allowed to carry.

There has been a good deal of discussion as to the advisability of teaching shop work in the university, the claim being made that more shop work can be learned in the factory in one week than in a whole university course. This may be the case where shop work is badly taught, but is not so when the object of the instruction is to familiarize the student with modern shop operation and processes, and with the workability of materials used in engineering construction, to give him information on the principles of manufacturing, duplication of parts and in the selection and arrangement of shop equipment. In the foundry, for example, besides receiving instruction in moulding, core making, mixing of metals, etc., consideration is given to the methods and appliances for sweep work and production in large quantities. In the machine shop, instruction is given in the use of semi-automatic and automatic machines, a few standard pieces turned out in large quantities being made for local manufacurers. The administration of the shop is intended to illustrate proper methods of shop management and operation, and to give the student a general idea of time keeping, piece work, premium work and other wage systems.

The work in the shops is all done from working drawings, and the courses in drawing, design and shop work are so organized as to secure the close correlation of these subjects.

METHODS OF INSTRUCTION.

Theoretical instruction is given in lecture and recitation classes. The tendency of the lecture system is to make the student procrastinate and put off studying the subject until

FIRST TERM SCHEDULE.

THIRD YEAR. ELECTRICAL ENGINEERING.

Week.	Lecture and Recitation Topic.	Reference.	Computing Room Topic.	Laboratory Topic.
1	Resistance	Art. 21–30	Resistance	Study of laboratory wiring
2	Wiring and illumination	Art. 381, 390, 392, 399	Wiring of buildings	Fuses and circuit-breakers
3	Linedrop	Art. 28–31	Wiring of buildings	Measurement of resistance
4	Work and power	Art. 16–20	Wiring of buildings	Study of meters
5	Rheostats	Art. 32–38	Rheostat design	Tests of iron
6	Magnetic circuits	Art. 39–41	Magnetic circuits	Electromagnets
7	Magnetic circuits	Art. 42–44	Examination	No-load tests on motors
8	Electromagnets	Art. 46–58	Design of electromagnet	Starters and controllers
9	Direct-current generators	Art. 12–18–63–68	Generator problems	No-load tests on generators
10	Direct-current armature windings	Art. 57, 62, 69	Generator problems	Armature winding
11	Commutation	Art. 70, 74	Generator problems	Generator load tests
12	Armature reaction	Art. 75, 79	Generator problems	Generator load tests
13	Direct-current generator characteristics	Art. 80, 85	Generator problems	Motor load tests
14	Direct-current motor operation	Art. 86, 92	Motor problems	Motor load tests
15	Direct-current motor characteristics	Art. 93–104	Motor problems	Speed centrol
16	Efficiency and losses	Art. 105, 112	Examination	Stray power tests

The text for recitation is Gray, "Principles and Practice of Electrical Engineering," and for laboratory is Karapetoff, "Experimental Electrical Engineering."

just before examination time, when much cramming has to be done. If the course happens to be one in which three or more lectures are given each week, the student becomes swamped, and cannot get the full benefit of the lectures, because he has not mastered what has gone before. Because of this, the large classes are subdivided into groups of about fifteen men each and placed under capable instructors. The work of the recitation is assigned in a particular text, and the student is expected to put in at least two hours of preparation, and then in the recitation to present his difficulties, and have them discussed by the instructor. It might seem that this works a hardship on the able student, because he is held back to the speed of the average student; but this is not necessarily the case if the recitation groups are selected so that the able men discuss more difficult problems during the recitation hour. A two-hour course if given to a large class will generally consist of one lecture and one recitation each week. The lecturer will treat the subject broadly, and will leave the details for the recitation hour. The student does not have to take lecture notes, because he is examined on the work of the recitation, and that work follows a good text book.

American students object to the taking of lecture notes, and will generally arrange that when a text book is not closely followed the teacher shall hand over his notes to a student committee, which will have copies made and sold to the members of the class.

A large number of problems are set for home work during the first two years. The number of such problems is reduced for advanced students, and the laboratory and design classes are arranged so as to give a thorough drilling in the application of theory. In the engineering laboratories the men work in groups of three, but each student has to hand in for correction a written report, which must include the theory of the experiment, the experimental results and a discussion of these results. The men are left to their own initiative, and the laboratory instructor is supposed to maintain discipline and be available for reference; but is not supposed to instruct the students or to help them in the carrying out of the experiment.

The complete schedule of work is made out at the beginning of the term under the supervision of the head of the department, and this schedule, the result of experience with previous classes, is adhered to rigidly, so that a teacher cannot allow himself to be side-tracked, nor is there the usual rush at the end of the session to cover the necessary ground. A typical schedule for the first term of the third-year electrical work is given below, as also are samples of the instruction sheets which are handed to the students in the computing room and in the laboratory.

THIRD YEAR—ELECTRICAL ENGINEERING.

Problem Work for 11th and 12th Weeks in Computing Room.

Subject.—No-load Characteristics of a Direct-current Generators.

The following data are given for a direct-current generator:

Poles	Four
Output	25 kw.
Volts	120
Speed	900 revs. per min.
Slots	49
Conductors per slot	Eight (0.06 × 0.32 in.)
Coils	98 (multiple winding)
Turns per coil	Two (mean turn = 50 in.)
Commutator bars	98
Brush studs	Four
Brush shift	18 electrical degrees
Pole enclosure	0.7
Shunt field winding	1,400 turns per pole of No. 14 B. & S.

1. Plot the no-load saturation curve from the following data:
Volts: 6, 20, 40, 60, 80, 100, 110, 120, 125.
Field current: 0, 0.14, 0.36, 0.59, 0.9, 1.4, 1.85, 2.87, 3.6.

2. If the speed is constant at 900 revs. per min., plot no-load terminal voltage against resistance of the field coil circuit for the following cases:

(*a*) Separately excited from a 110-volt line.
(*b*) Self-excited and shunt connected.
(*c*) Self-excited and compound connected.

Which machine is most sensitive to field rheostat adjustment?

3. Specify the graded field rheostat to change the voltage from 120 to 40 volts for the three connections. The resistance of the shunt field winding is 35 ohms.

4. With the field circuit rheostat short-circuited, find the terminal voltage at speeds of 225, 450, 900 and 1,250 revs. per min. if the machine is

(*a*) Separately excited from 110-volt mains.
(*b*) Shunt-excited.

Which machine is most sensitive to change of speed, and explain why it is so without mathematics and without reference to the figures found above?

Subject.—Load Characteristics of Direct-current Generators.

1. Draw the external characteristic from no load to 50 per cent. overload for the above machine when separately excited, the no-load E.M.F. to be 120.

2. Find the number of series turns required for flat compounding, and find the size of wire for the series coils, allowing 1,000 amperes per square inch. Why can the current density in the series coils be greater than the shunt coils, in which it is 888 amperes per square inch?

3. Draw the external characteristic of the above machine as a shunt generator, the no-load E.M.F. being adjusted to 120 volts.

Laboratory Work for 11th and 12th Weeks.

Subject.—Direct-current Generator Characteristics (non-Interpole Machine).

Object.—To determine how the terminal voltage of a constant-speed generator varies with load:

(*a*) The machine separately excited.
(*b*) The machine shunt excited.
(*c*) The machine compound excited.

Reference: See Karapetoff, "Experimental Electrical Engineering"; Gray, "Principles and Practice of Electrical Engineering," pages 71–77.

Note.—The terminal voltage should be adjusted to the same value on no-load for each test. Do not forget to measure the cold and hot resistances of the armature circuit.

Report.—The report should contain, in addition to the original data sheet:

(*a*) Object of experiment and list of apparatus used,
(*b*) Short outline of theory,
(*c*) Answers to specific questions given below,
(*d*) Diagrams of connections, using standard conventions,
(*e*) Observed and computed data, with sample computations,
(*f*) Curves prepared in accordance with practice,
(*g*) Discussion,
(*h*) Original data sheets.

Note that the theory must not be copied directly from the text, nor should the report be a disjointed set of answers to questions. The curves and data must be in ink, and the final grade of the report will depend on the accuracy and clearness with which it is expressed, the neatness and orderliness of the arrangement, and the way in which the work is carried out in the laboratory.

Questions:

1. Why does the terminal voltage of a separately excited generator decrease with increase of load? How much of the drop at full load is due to the armature resistance?

2. Why is the voltage drop greater in the shunt than in a separately excited generator?

3. What would be the effect of shifting the brushes further forward from the neutral portion?

4. What is the principal advantage of the compound generator?

5. How would the terminal voltage of a compound generator vary with increase of load if the series field coils were connected so as to oppose the shunt coils?

6. If the generator is over-compounded while flat compounding is desired, what can be done to fix the machine?

7. If the voltage of a shunt generator builds up when the generator rotates in a given direction, will it build up if the direction of rotation is reversed?

The work of the computing room in the fourth year consists largely of the predetermination of the characteristics of machinery and the selection and arrangement of the electrical apparatus required for power generation, transmission and distribution. An induction motor problem is given below to which not less than eight computing periods, each of three hours, would be devoted.

Course E 21. Due on May 18th. Second Term, 1917–18.

INDUCTION MOTOR DESIGN.

Data: 75 H.P., 440 volts, three-phase, 60 cycle, 720 syn. revs. per min.

	Stator.
External diameter	33 in.
Internal diameter	26 in.
Frame length	6.5 in.
Centre ducts	None
End ducts	Two, each 0.5 in.
Slots per pole	12.
Size of slot	0.36 in. by 1.6 in.
Cond. per slot	10.
Winding	YY.
Size of cond.	0.11 in. by 0.22 in.
Air-gap	0.035 in.

Requirements:

1. Re-design the stator for a motor rated at 100 H.P., 440 volts, three phase, 60 cycle, 720 syn. revs. per min., using the same punchings as for the 75 H.P. machine given above.
2. Design a squirrel-cage rotor to give a starting torque of 1.5 times full-load torque, with a full applied voltage for the 100 H.P. machine.
3. Design a phase-wound rotor for the 100 H.P. machine; specify the external resistance required to give maximum starting torque, and also that for full-load torque with full-load current in the stator.
4. Fill out design sheet similar to that on page 402 of Gray's design, and make freehand sketches showing the approximate proportions and the mechanical and electrical construction of the machines.
5. Draw a circle diagram for one of the motors, and tabulate a few characteristic values from it. Check the performance data at some load with those obtained from the equivalent electric diagram.

Option:

Extra credit will be given for an investigation of the performance of the machine as induction generator.

Initiative, resourcefulness and *originality*, as well as a *clear and forceful* presentation of the *results* in the report, will be given considerable weight in the mark.

Reference: Gray's "Elect. Mach. Design," Chapters XXVII.–XXXIX.

The work of the senior laboratory is of a more advanced nature than that of the third year. At Cornell University it has been found satisfactory to give the student a large number of suggestive questions around which he can write a report. Such a set of questions, along with the laboratory instructions, are given below for an experiment on the alternator, which experiment will require one hour of study in class before the experiment is performed, two afternoons of work in the laboratory, and a minimum of ten hours for the write up. Many of the students will prepare what is almost a treatise on the subject.

EXPERIMENT NO. 16—TESTS ON ALTERNATORS.

Object:

(*a*) To predetermine the efficiency of an alternator from the total losses, including the load losses, and draw the efficiency curves for 100 per cent., and also for 60 per cent. power factor.

(*b*) To predetermine the regulation from no-load and short-circuit tests, draw the regulation curves for 100, 80 and 20 per cent., also zero power factor, and compare the 100 per cent. power factor curve with test curve.

The following order of procedure is generally followed in practice:

1. Make no-load saturation and core loss test.
2. Find the stray power loss.
3. Make the short-circuit test, and at the same time measure load losses.
4. Draw the no-load saturation curve, also the optimistic and pessimistic curves for full-load current and zero power factor.
5. Make the full-load saturation test at approximately zero power, using a synchronous motor for load.
6. Take data for regulation curve at 100 per cent. power, factor up to 25 per cent. overload, keeping exciting current constant.

Note.—When shutting down, keep exciting current constant and note that short-circuit current is practically independent of frequency. What is the explanation?

The following curves must appear in the report:

A. No-load saturation.
Short circuit.
Synchronous reactance.
Optimistic.
Pessimistic.
Experimental, zero power factor full-load saturation.
Computed 80 per cent. power factor full-load saturation both leading and lagging.

Computed 20 per cent. power factor full-load saturation both leading and lagging.

B. Regulation by calculation at 100, 80 and 20 per cent., and zero power factor both lagging and leading. Take synchronous reactance from actual zero power factor saturation curve.

C. Losses against full-load current at 100 and 60 per cent. power factor lagging.

D. Efficiency against kilovolt-amperes at 100 and 60 per cent. power factor lagging. Give necessary theory and vector diagrams.

Course E 28. EXPERIMENT NO. 16. 1917–18.

Question Sheet on Alternators.

Reference: Karapetoff, Arts. 558–560, 572–574, 577, 578, 581–583.

A. Answers should be known before recitation hour.

1. What are the three important points in the performance of an alternator with respect to which guarantees are usually made in contracts of sale?

2. What are the losses in an alternator? How is each of these losses determined experimentally? How is efficiency obtained from losses?

3. An alternator is rated in kilovolt-amperes and the efficiency is guaranteed at 85 per cent. power factor. What do you take for the alternator output?

4. What factors affect the regulation of an alternator?

5. How are these factors affected by a change in power factor with a given kilovolt-ampere output?

6. Which of these factors has the greatest effect at unity power factor? Which at zero power factor? Explain by vectors.

7. What is meant by ''optimistic'' and ''pessimistic'' limits of regulation of an alternator?

8. What attachment would have to be made to the alternator to make it self-exciting?

9. How would the excitation vary with the current remaining constant, power factor varying?

10. Why is it not possible to test a 10,000 k.v.a. alternator by input output method?

11. If it could be done, would it be more accurate than by method of losses?

B. To be taken up in recitation.

1. Give the general theory of the optimistic method of predetermining regulation.

2. Give the general theory of the pessimistic method.

3. What is meant by synchronous reactance?

4. Are there any methods which give more nearly correct values than either of the above?

5. Why does the synchronous reactance obtained from load test at zero power factor differ from the synchronous reactance from short circuit?

6. What is meant by armature reaction? How does it affect regulation?

7. What is meant by stray load loss? How obtained?

8. What excitation loss do you use to meet guarantee in question A3?

9. Why has the rotating field construction superseded the rotating armature type except for small low voltage machines?

C. Answers to the following must be known.

1. Describe in detail the method of obtaining armature copper loss from the short-circuit run.

2. Is this greater or less than the I^2R loss? Why?

3. In computing copper loss from the short-circuit run, should the iron loss be taken into consideration?

4. Having obtained the regulation curve for zero power factor, how do you obtain the regulation for any other power factor?

5. How does the predetermined regulation for 100 per cent. power factor differ from the experimental regulation? Give reasons.

6. In purchasing an alternator, what points in guarantee would you be most insistent upon having fulfilled?

7. Note that regulation at 20 per cent. power factor load is little better than at zero power factor load.

8. Alternating-current generators were formerly designed with 6 and 8 per cent. inherent regulation at 100 per cent. power factor. To-day very little attention is paid to regulation, and regulations of 15 to 20 per cent. are common. What factors have led to this change?

9. Why is such poor regulation satisfactory in practice?

D. Other questions of interest:

1. Why are delta windings used so little as compared to star-connected windings?

2. Why are reactances sometimes used in leads from alternating-current generators to bus bars?

3. Why are reactances sometimes used in feeders from bus bars to load?

4. Do synchronous motors constitute a more or less favorable load for alternating-current generators than induction motors of corresponding ratings?

5. If a turbo-generator is guaranteed to meet a rise of 50 deg. by thermometer, but on test shows a rise of 45 deg. by thermometer on the coil ends, 90 deg. rise by thermo-couple at the hottest part of the coil within the core, would you accept the generator in spite of its failure to meet the guarantee by thermometer?

6. How should temperature rise be specified in contracts for large turbo-alternators?

7. When two generators are operating in parallel, what holds them together? Why is it that two generators connected in series will not stay in synchronism unless mechanically connected?

8. A plant was installed with engine, generator and boiler capacity to operate a 75 per cent. power factor load. Power factor is raised to 100 per cent. by synchronous motors, but the kilovolt-ampere output is unchanged. Will the plant operate satisfactorily?

9. Would the instantaneous short-circuit current be the same for a given field excitation as was obtained in the short-circuit run?

Penalties.—A very elaborate system of prerequisite subjects is enforced, so that, for example, a student is not permitted to enter the second year physics course until he has passed the physics and mathematics of the first year, nor is he permitted to take the electrical engineering course of the third year unless he has passed the physics, mechanics and electrical engineering of the second year. Students who have failed in one or more subjects cannot, therefore, graduate on time, and considerable care is necessary in planning their work, so that class advisers are appointed who see that the students do not get into difficulties. Each student has his study card checked up by the class adviser, and is not allowed to take more work or less work than is stated thereon. If a student finds that his work is becoming too heavy, and that he wants to drop part so as to do the remainder successfully, he has to consult with his class adviser as to what part may be dropped. No student is allowed to take less than 17 credit hours per term or more than 20 unless special permission is granted by the petition committee. The pass mark in most colleges is 60 per cent., this being the average mark obtained from the class examinations and from the mark obtained in the daily recitations and in the computing room. Three times during each term the whole class record is sent over to the department office, and those whose work in one or two subjects would indicate that they are not progressing satisfactorily, are called before a delinquency committee and asked to state the reasons why the work is unsatisfactory and what they expect to do to get it in shape again. By this means loafing and unsystematic study is discouraged. If the student obtains a class mark in any subject between 40 and 60 he is given a conditional mark and allowed to proceed with his work; but he must pass what is called a make-up examination within one year after obtaining the condition, and if he fails in this trial he has to repeat the work over in class. Any student who obtains a mark below 40 is not allowed to proceed with that subject. At the end of the term the records of those students who have obtained conditions or failures in one or more subjects is brought up before the doubtful case committee. If a student has obtained a condition in more than one third of his work he is put on probation, and if his record is very bad, so that the committee feels that he cannot proceed and do justice to his work and to his teacher, he is asked to leave college for the remainder of the year and come back and repeat all of his unsatisfactory work. In this way he graduates one year later than the rest of the men in the class.

Regular attendance is required at all meetings of the class, the roll being taken by having a seat assigned to each student, and the names of the students who should be in the vacant seats are noted by the janitor or by an instructor. The attendance record is displayed, so that the student may verify his record. If the student is absent without excuse from more than 10 per cent. of the meetings of the class he is dropped from the course, and excuses can be obtained only when a doctor's certificate is shown. If a student has a considerable amount of sickness, and has done creditable work until taken sick, he is given a mark of ''incomplete'' and allowed to make up his unfinished work when he can find time.

The laboratory reports have to be handed in for correction within one week of the date on which the experiment was performed. If this report is unsatisfactory it is handed back for correction, for which another week is allowed. A report which is more than two weeks late is given a grade of zero.

The reasons why a student may be put on probation have already been stated. No student on probation can represent the university either individually or with any student organization either at home or abroad, nor can he take part in any student activity or hold any class office, nor be a member of any athletic team or student organization. A student is removed from probation only by the completion of one whole term of satisfactory work.

These many restrictions will appear rather strange to teachers in England, but have been found necessary in order to maintain a high order of scholarship, especially when the classes are large. Before the war the engineering colleges of America were graduating about 4,000 students each year, and, in spite of the restrictions mentioned, only about 40 per cent. of the men who enter the university graduate in the four years. The greatest elimination takes place in the second year, when many students find that they cannot stand the pace, while others decide that they have entered the wrong profession. One of the problems of the American colleges is to maintain a high average of scholarship by enforcing discipline and still take care of the development of the few students of unusual ability who do not, as a rule, thrive well under ironclad rules.

Student Organization.—It is impossible to discuss the many student activities but the student organization cannot be overlooked. In America the undergraduate body is organized according to the year in which they expect to graduate; thus the class of 1920 contains all arts, science, medical and law students who expect to graduate in June of that year. Such a method of organization is better than one in which the students are grouped together according to the college to which they belong, because the engineering student meets young arts, medical and law students at the class functions, and begins to appreciate that all lawyers are not crooks, that medical men are not infallible, and that arts students may be live men even although they are studying dead languages. Since the engineering colleges are generally the stronger numerically, and since they take their full share in athletics and in other student activities, there is no tendency on the part of even the faculty of the college of arts to consider the engineering student as an educated plumber. Many of these students do a considerable amount of work in the arts college and elective subjects, such as psychology, public speaking, English literature, history and economics, are very popular.

The type of instruction just described is typical of that given at practically all of the engineering schools; but there are signs that changes may be expected, particularly along the line of closer correlation with industry and with the purpose of eliminating unsuitable students earlier than in the second year, and also testing and grading students for initiative and judgment as well as for their ability to pass examinations. Much information on these subjects will be found in the TRANSACTIONS and PROCEEDINGS of the Society for the Promotion of Engineering Education, and it is hoped that a better understanding of the discussions of this society will have been made possible by the information contained in this article.

POLARIS OBSERVATIONS FOR AZIMUTH IN NORTHERN LATITUDES.

BY J. MAUGHS BROWN,

Professor of Civil Engineering, University of South Dakota.

Usual Methods.—The problem of finding a true or astronomical meridian is one that nearly every civil engineer and surveyor has to solve at some time or other, and in certain classes of work quite frequently.

There are two general well-known methods of obtaining a true meridian which are popular with engineers. These are sun observations and Polaris observations. When an error of from one to two minutes of azimuth is admissible, the former is preferred by many engineers. A solar observation for meridian may be made very easily during the usual time of work in the field by taking either direct observations on the sun in altitude and azimuth, and computing the true azimuth of the sun by means of the formula

$$\cos z = \pm \frac{\sin d}{\cos h \cdot \cos L} - \tan h \cdot \tan L \qquad (A)$$

or

$$\cot \tfrac{1}{2} z = \sqrt{\frac{\sin \frac{1}{2}(h + p - L) \cdot \sin \frac{1}{2}(L + p - h)}{\cos \frac{1}{2}(L + h + p) \cdot \cos \frac{1}{2}(L + h - p)}} \qquad (B)$$

or by means of a solar attachment to the transit.

There are many engineers who much prefer to secure meridian by means of observations on the north star on account of the somewhat greater simplicity of instrumental manipulation and the better accuracy obtained. The additional advantage of great simplicity of computations is only secured when the observations are made at the time of elongation of Polaris in its apparent orbit, or near that time. The method has long been recognized as one combining great simplicity and great accuracy. After observing Polaris the well known formula:

$$\sin Z = \sin p / \cos L,$$

where the terms have the significance given later, serves to give the azimuth.

The great disadvantage in the elongation method is that at certain times of the year the star comes to the position of elongation at very inopportune times of the night, making it very disagreeable to sit up and wait for the proper time, frequently many weary miles from camp or home. In the fall and spring, when Polaris comes to elongation early in the evening, the elongation method is without an equal. At other times, in order to avoid a long vigil or a midnight ride, Polaris may be observed for azimuth about dusk and the azimuth computed from the formula:

$$\tan z = \frac{\sin t}{\cos L \cdot \tan D - \sin L \cdot \cos t} \qquad (C)$$

for azimuth at any hour angle. Although under favorable conditions the element of accuracy is still retained, for the average engineer who does not make such observations very frequently the element of simplicity has a slightly clouded title. This is due to the fact that in the use of the formula (C) above, both conversions of time and a longitudinal correction must be made. Also, for accuracy, the time of the observation should be known very closely. If the surveyor happens to be out on an extensive survey in thinly settled country where accurate time is not at hand, he must either secure the same by another observation or by making a comparison with the nearest accurate time piece, or else he will feel uncertain as to the accuracy of his results.

Following will be given methods which will secure results of the desired accuracy with a minimum of field work and computations that are not difficult.

Special Methods.—The field operation will be given in detail first followed by the theory upon which the field work is based.

Field Procedure.—Go into the field at any time after dusk and set up the transit at the desired point with the vernier of the limb set at 0°. It should be needless to caution that the instrument must be in excellent adjustment and accurately leveled. The last operation is best accomplished by means of the telescope bubble. Select a pair of stars that you have data on that are approaching a position of both coming to the same vertical of the observer. Say you select α and γ Ursa Major. (See Fig. 1.) Follow the stars in their apparent motion with the vertical wires of the transit until they both arrive on the same vertical, at which time they will both have the same azimuth or bearing from you. Unclamp the upper motion of your transit, sight on Polaris, bring the line to the ground and set a tacked hub. Now read the angle between the stars and Polaris. Or, after reading the angle between the stars and Polaris, the azimuth may be referred to a line of the survey instead of placing the tacked hub under the pole star. From a table similar to the following, whose method of preparation is given later, take out the azimuth of the stars, interpolating for your latitude by means of the curves shown in Fig. 3. From the hour angle of the stars the hour angle of Polaris as given in the table is obtained by noting the difference in right ascension.

Using the hour angle of Polaris as the argument, enter a table of azimuths of Polaris at different hour angles such as found in the American Ephemeris and Nautical Almanac or the Manual of Surveying Instructions for U. S. Deputy Surveyors. The azimuth of Polaris added or subtracted to the azimuth of the stars first obtained should check the angle read on the instrument.

If a field check is not considered essential, the azimuth of the pair of stars should give a fair degree of accuracy, but in this event better accuracy could be secured by taking Polaris and some other circumpolar as the pair and computing the azimuth of Polaris at the instant the two stars come to the same vertical in exactly the same manner. This does not give a field check, but is otherwise a very desirable method.

Theory.—By reference to Fig. 1, a chart of the circumpolar stars, it is apparent that as the earth revolves on its axis, the circumpolar stars will travel in apparent orbits about the point in the heavens where the axis of the earth produced intersects the assumed celestial sphere.

Mainly on account of the motion of the celestial equator with reference to the ecliptic, the location of the celestial pole and the true circular apparent motion of the stars remain in

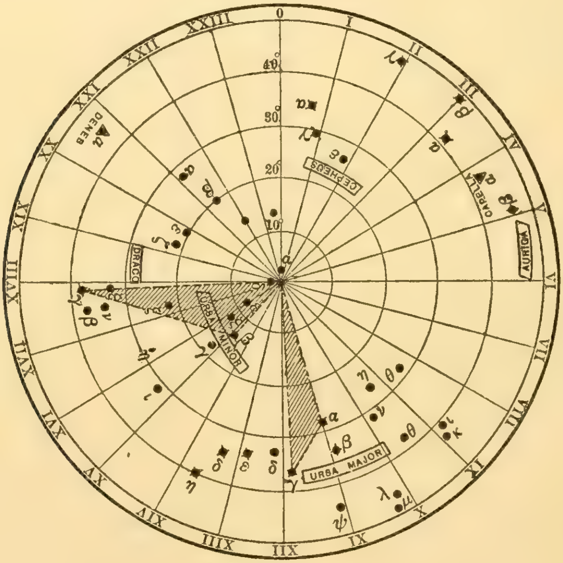

FIG. 1.

the same relative positions only for a somewhat short period of time, astronomically speaking. But this period of time in many cases is long enough to be practical in surveying computations. The changes above referred to are both small and gradual, and they will not be here discussed. The apparent positions of the stars may be found at any time by reference to the American Ephemeris above referred to.

The following notation will be used:

Let

Z = zenith of the observer.
A = celestial north pole.
p_1 = polar distance of a circumpolar.
p_2 = polar distance of another circumpolar.
d = declination of a star.
t = general symbol for a time angle.
h = general symbol for the altitude of a star above the horizon.
ϕ = difference in the right ascension of two stars.
C = hour angle of the star whose polar distance is p_2.
L = latitude of the observer.
Co-lat. = the co-latitude of the observer = $(90° - L)$.
z = a general symbol for azimuth.

In triangle 1 (Fig. 2), the relationships existing, which may also be seen by reference to Fig. 1, will remain nearly constant for some length of time, so that the triangle formed by two

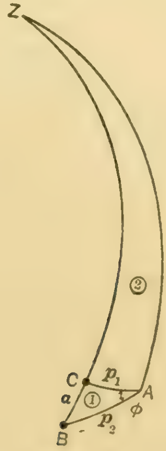

FIG. 2.

selected circumpolar stars and the pole as the vertices will appear to revolve about the celestial pole as an axis. Then from the data pertaining to these stars selected from the ephemeris, the remaining side a of this triangle may be computed by trigonometry. This value of a should remain good for the purposes here proposed for some length of time.

From trigonometry we may write

$$\cos a = \cos p_1 \cos p_2 + \sin p_1 \sin p_2 \cos \phi, \tag{1}$$

$$\sin B = \sin \phi \frac{\sin p_1}{\sin a}. \tag{2}$$

Equations (1) and (2) give us complete data on the triangle 1 of Fig. 2, the values of B found from equation (2) being independent of the latitude of the observer.

In the circular motion of triangle 1 about the celestial pole there will be found a place where the two stars under consideration will come to the same vertical, or in other words have the same azimuth from the observer. In this position the side a (CB) of triangle 1 will coincide with the side ZB of triangle ZAB, or triangle 2, therefore angle B of triangle 1 will be the angle B of triangle ZAB for any latitude.

Solving triangle ZAB for the azimuth of the stars, we may obtain from trigonometry

$$\sin z = \sin B \sin p_2 \sec L. \tag{3}$$

Calling $\sin B \sin p_2$ a constant for a given period of time

$$\sin z = K \sec L,$$

and if no check is desired this is as far as the work need be carried.

By substituting the value of $\sin B$ from equation (2) we have

$$\sin z = \frac{\sin \phi \sin p_1 \sin p_2 \sec L}{\sin a}, \tag{4}$$

or as before,

$$\sin z = K \sec L,$$

where

$$K = \frac{\sin \phi \sin p_1 \sin p_2}{\sin a}.$$

By solving equations (1) and (4), azimuth may be obtained from the position of any two stars coming to the same vertical with a small amount of labor, but in order to introduce the field check we must solve the triangle *ZAB* for the hour angle of the lower star. This gives the angle at *A* (Fig. 2).

From trigonometry

$$\cot \tfrac{1}{2} A = \frac{\sin \frac{1}{2}(p_2 + \text{Co-lat})}{\sin \frac{1}{2}(p_2 - \text{Co-lat})} \tan \tfrac{1}{2}(Z - B). \qquad (5)$$

As this value for *A* varies with the latitude, it should be solved in the office for two or three values including the limits of the surveying territory to be covered. In the example tables given below a much wider range has been given than is

DATA FOR TWO STAR CHECK METHOD FOR AZIMUTH.

Stars Selected, γ Draco and β Ursa Minor. β Above.

Latitude.	Azimuth of Pair.			Hour Angle of Polaris.		
°	°	′	″	h.	m.	s.
35	17	13	20	6	18	0
36	17	26	40	6	19	32
37	17	40	40	6	21	7
38	17	55	30	6	22	44
39	18	11	00	6	24	24
40	18	27	30	6	26	4
41	18	44	40	6	27	54
42	19	2	50	6	29	44
43	19	22	00	6	31	37
44	19	42	10	6	33	34
45	20	3	30	6	35	34
46	20	26	00	6	37	42
47	20	49	50	6	39	53
48	21	15	00	6	42	5
49	21	41	40	6	44	30
50	22	10	00	6	47	3

Values for azimuth taken to the nearest 10 seconds.

at all needed. Intermediate values may be interpolated by means of curves similar to the ones drawn if the tables are worked for the even degrees of latitude only. For the majority of large surveys three or four degrees at most are enough.

The data given above is for γ Draco below and β Ursa Minor above, and computed for 1918 but may be used for several years and an error of one minute in azimuth not exceeded. Hour angles given in sidereal time.

Stars Selected, a and γ Ursa Major. a Above γ.

Latitude.	Azimuth of Pair.			Hour Angle of Polaris.		
°	°	′	″	h.	m.	s.
35	23	54	30	1	9	49
36	24	13	40	1	12	35
37	24	33	50	1	14	55
38	24	55	00	1	17	16
39	25	17	20	1	19	40
40	25	41	00	1	21	29
41	26	5	50	1	24	41
42	26	32	00	1	27	20
43	26	59	50	1	30	03
44	27	29	00	1	32	58
45	28	00	10	1	35	50
46	28	33	00	1	38	55
47	29	07	50	1	42	06
48	29	44	40	1	45	34
49	30	24	00	1	49	00
50	31	05	50	1	52	38

If Polaris is used as one of the two stars, the solving of only two equations (1) and (4) will give the azimuth very accurately. By solving equation (5) the sidereal time of the observation may also be computed.

If the latitude of the observer is not known with a sufficient degree of precision, an additional reading of the elevation of Polaris, or of some other star, as it passes the approximate meridian determined from the data at hand will give a close value for the latitude that in turn may be used to find a correct value for the azimuth, all the field work being accomplished at one setting.

Curves for Interpolating Hour Angles and Azimuths for the above Table.

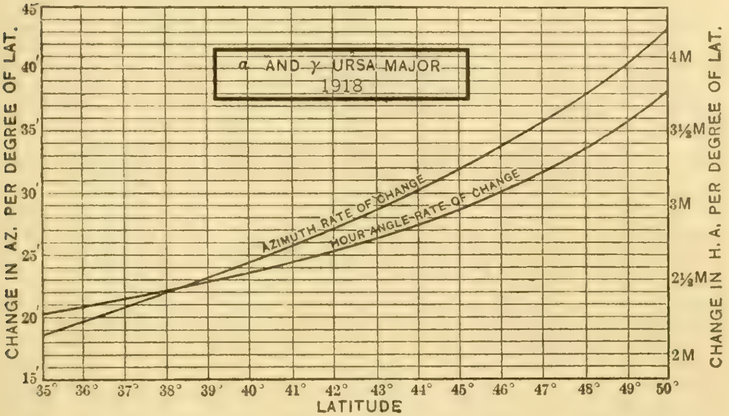

Fig. 3.

If only a few observations per season are to be made it is evident it will hardly be necessary or worth while to go to much trouble to prepare tables. The constant *K* for Polaris in combination with several other stars may be computed in the office for a season and used to obtain azimuth. This involves very little labor on the part of either the office or the field, and is very accurate and convenient. Following are the computations of an example.

Example:

Date—April 24, 1918. Latitude 42° 47′ N.

The stars selected in the field as convenient were Polaris and γ Celphi.

From the Ephemeris:

	Polaris.			Celphi.		
Right Ascension	1^h	29^m	58^s	23^h	35^m	56^s
Polar Distance	1°	7′	50″	12°	49′	30″

$$\phi = 1^h\ 54^m\ 2^s = 28°\ 30.4'.$$

From equation (1). Let $\cos a = L + M$,

$\log \cos p_1 = 9.99992$
$\log \cos p_2 = 9.98903$
$\log L \qquad 9.98895$
$L = .97488$
$M = .00385$

$\log \sin p_1 = 8.29514$
$\log \sin p_2 = 9.34630$
$\log \cos \phi = 9.94387$
$\log M \qquad 7.58531$
$M = .00385$

$.97873 = \cos a, \; a = 11° \; 50' \; 20''$

From equation (2)

$\log \sin \phi = 9.67876$
$\log \sin p_1 = 8.29514$
$\log \sin p_2 = 9.34630$
7.32020
$\log \sin a = 9.31209$
$\log K = 8.00811$
$\log \cos L = 9.86565$
$\log \sin z = 8.14246$

$z = 0° \; 47' \; 43''$ about.

The value of log K here secured may be used until the stars are no longer visible on account of arriving on the vertical position too early in the evening. In subsequent obser-

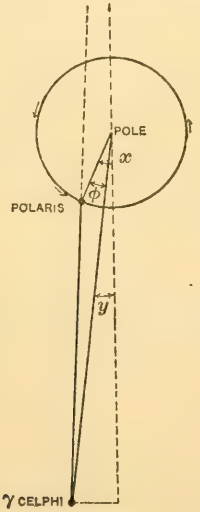

FIG. 4.

vations on these two stars it is then only necessary to multiply by log sec L to obtain azimuth.

A simple rough method of obtaining the azimuth at the above instant will be given. This may be used as a check on the above or in certain cases may suffice.

In Fig. 4 assume that the angles x and y are inversely as the polar distances of the stars Polaris and γ Celphi.

Then

$$x - y = \phi,$$

and

$$\frac{y}{x} = \frac{68}{769},$$

$$y = .088\,x,$$

$$x(1 - .088) = \phi, \text{ Difference in R.A.}$$

Solving for x gives a value of about 2 hours and 5 minutes.

Entering a table giving the azimuth of Polaris at all hour angles, or computing it by one of the approximate formulas, gives a value for z of about 47′ 20″.

The larger the difference in polar distance of the star selected from that of Polaris, the more accurate the rough method becomes. It also increases in accuracy as the stars selected come closer to the meridian.

The more precise computations first given may be somewhat differently arranged by using the tangent formula,

$$\tan B = \frac{\sin\phi \sin x \sin p_1}{\sin p_2 \sin (x - p_1)} \tag{6}$$

where

$$x = \cot^{-1}(\cot p_2 \cos\phi),$$

to compute the angle B, and then z found from

$$\sin z = \sin B \sin p_2 \sec L. \tag{3}$$

As equation (6) is similar to the equation (C) ordinarily used to compute the azimuth of Polaris at any hour angle, a comparison with the usual hour angle method may be made by comparing the labor of solving the simple equation (3) to that of looking up and obtaining the relations between the different forms of time, and making a proper correction for longitude. The advantage is clearly with the method here given on the computation score alone, for one observation. When it is considered that in this method one computation may be made to serve for several observations, and that no time considerations enter whatsoever, and that there are no unreliable refraction corrections to make, and that a transit without a means of reading vertical angles may be used; the methods may be used to advantage by many engineers who now refrain from making the usual hour angle observations.

DISCUSSION OF REPORT OF COMMITTEE NO. 15 ON METHODS AND DETAILS OF TEACHING STRUCTURAL DESIGN.

The preliminary report of the committee was published in the June, 1918, BULLETIN. It consisted of three papers as follows: "The Object of the Structural Courses," by H. T. Burt; "Subject Matter," by C. T. Morris; "Training of Instructors," by J. Hammond Smith. The following discussions were based upon these and upon the chairman's presentation at the Evanston meeting by A. H. Fuller. The presentation, together with the three papers appears in the 1918 *Proceedings.*

BY CHARLES EVAN FOWLER.

The objects of the structural course should be to give the student a thorough grounding in the fundamentals of the theory of structural design, which must form the tools and weapons for his future development into a structural engineer and constructor. Like one who first learns the grammar of a foreign language, and then acquires the vocabulary by practice, the student must learn to think in moments, shears, and other basic theory, and then in practice acquire all the multitude of applications of this basic theory to real design that will in time give him that proficiency which makes the true engineer.

This presupposes that he is thoroughly equipped with the fundamentals of a common school education, and is endowed with a reasonable amount of common sense, without which he cannot hope to make a great success in any branch of engineering or applied science. The question must be answered in the first year or two of his college work in engineering as to whether he is suitable material from which to make a structural engineer, or in fact, any kind of an engineer. The writer firmly believes that the greatest mistake that is being made by engineering educators of to-day, is the attempt to make engineers of all members of an engineering class. The story is quite to the point of the young man who called upon his minister, saying that he had seen in his dreams the letters P. C., and felt this to mean that he was to Preach Christ. After a thorough questioning, he was told that he was mistaken, and that the letters in his case meant to Plow Corn! How much the world was saved in that case represents only a small percentage of the good that would result to the world if at the end of the freshman and again at the end of the sophomore year, a really thorough weeding out process could be followed, and many students directed to follow some other course of study or else some other branch of engineering than the one selected upon entering college. The truth of this is so clearly proven by the many cases of engineering graduates who eventually drift into business, manufacturing, or some other life work, and thus have wasted to some extent several of the best years of their lives. Therefore, it would seem that the purpose of the first year or two of a college course should be to determine the aptitude of the students for the life work they have chosen, and for this reason the studies prescribed for the freshman year should be such as would be good training, not only in engineering but for any life work; while for the sophomore year the studies should be largely those applying as a basis or ground work for any branch of engineering. The faculty of the engineering school should, therefore, provide a committee to sit in judgment upon the case of each student after he has completed the freshman year, and decide as to whether it is advisable for him to continue in engineering at all; and again at the end of the sophomore year to advise as to the particular branch of engineering for which each student is best suited. The teacher of structural engineering would in this way have a junior class each year, composed of students having a real and peculiar adaptability for that particular branch of engineering, thus greatly simplifying the teaching problem. There would still no doubt be many slip through who would in the end become only mediocre engineers, but on the whole great good would result both to the individuals and to the engineering profession. The objects of the structural engineering course would then become more definite, inasmuch as the dead weight of a large number of drones would be removed, and much less time be wasted than by attempting to reach a fair average for the entire original class. The students would progress freely from vantage point to vantage point, and the pseudo profession of structural engineer become a real one, instead of one merely in name as at present.

The fundamentals of mathematics and mechanics as applying to structural engineering could then be developed in their application to practical examples instead of from textbooks in a purely theoretical way; the applied method certainly being best for fixing in students' minds the fundamental principles, facts and formulas, not merely of structural design, but of structural engineering. The writer has found during a practice of over thirty years that experiences in business, in legal matters, and in all things other than engineering, have at some time or other been of a peculiar benefit in solving some particular engineering problem; and lucky indeed is the student who has learned before entering college many things in business, in law, and the common things of life. More especially if they have inoculated a high degree of system and method in his work, which are among the most difficult and the most necessary to develop in the engineering student, if he has not already developed these traits.

The other things besides these two essentials of system and method which should receive more attention in engineering schools, are self-reliance and initiative. Self-reliance begins to come to the student during his college work from a thorough understanding of fundamental theory, and his ability to apply it to the practical problems of his chosen profession; and the greater degree that he attains during his college life, the more rapidly will he acquire the full measure of it during the early years of work at real engineering, provided of course that he does not confuse cock-sureness with self-reliance.

Initiative is but a degree of inventiveness with which we as a nation lead the world; owing largely to the fact that necessity has been the mother of invention, especially with the pioneers during the formative periods of our history, and from them the later generations have inherited this faculty as a very striking feature of our national characteristics.

The structural engineer must daily, and often many times daily, work out details that are a test of his inventive ability, and which very frequently are real inventions, such as those other than engineers would often have patented. There is nothing more exasperating to the chief engineer, or one in charge of college graduates and young engineers, than to give to one of them the designing of all or part of a structure, and to have assertions made that this and that feature is impossible of solution. The somewhat exaggerated motto ''Nothing is Impossible'' was for many years kept on the walls of the writer's office where a large number of young designers were employed; but it had a most salutary effect, to the end that less assertions as to impossibilities were heard, and all but extremely difficult details came to be worked out as a matter of course. Nothing has pleased the writer more than to find that the scores of men working in that particular office during nearly a decade, have attained to more or less very responsible positions during the years that have followed such employment.

The scope of this discussion does not allow of a very extended exposition of the methods by which self-reliance and initiative can be developed during a college course, but I am sure that there is great merit in the suggestion that has been made to have engineering students devote some time to the study of invention. Whether this is made the subject of a separate study or not, there can be no question but what great good will result by the teacher requiring the student to find his own way of designing reasonably complicated details; and certainly during every year of the college course, in field work, in laboratory work, and in making designs, the student should be brought to face more or less difficult situations not beyond his powers of solution, and then required to find his own method of surmounting the difficulty or solving the problem.

The foregoing paragraphs have covered very largely not only the objects of the structural course, but the "subject matter," and the "manner of presentation" as well. The subject matter already included in the courses of our engineering schools is fairly comprehensive, and perhaps there is little need to dwell upon the necessity for a greater amount of time being devoted to construction methods, both of the fabrication and erection of steel structures, and the construction of foundations; there having been a great improvement at many colleges in this respect during recent years. These practical subjects can be presented by lantern slides, moving pictures, lectures by practicing engineers, etc., but the teacher should insist upon his pupil spending as much time as possible, especially during vacation, working for a good structural plant either as a draftsman or in some capacity on actual erection even if he is obliged to serve as a laborer or timekeeper. The benefit to the student will be immediately seen in his college work that follows, as he will usually show a greater interest in his studies and a quicker grasp of the subjects.

What is true in the training of the student, is true in an increased degree in the training of the teacher. He must know the theory perfectly, but he must know as well the practical application; and this knowledge can only be gained by some years of work at practical engineering, which should be supplemented by employment on construction work. Nothing is more disgusting to the student who has spent some time on actual construction work, than to have his teacher show more or less ignorance of practical matters; and the writer knows personally of students who have nearly allowed such continued exhibitions to wreck their college careers. The teacher should not only spend some years on practical work after his graduation, and before undertaking to teach engineering, but should spend as much time as possible during vacations, in engineering or construction employment.

The interchange of ideas between teachers through Society publications, and at conventions, has been the cause of marked improvement in the courses of study, the methods of teaching, and the results attained, but this will not suffice without a first-hand knowledge of the practical methods in use by practicing engineers and constructors. Much good often results in the introduction of new and foreign blood into the teaching staff of a college, and much that is bad often results from the immediate employment as instructor of a graduate by his alma mater; that is before he has had some years of practical experience, and before he has taught at some other school or schools; and has thus obtained that breadth of view that enables him to select from the many, those methods of teaching which give the best results and which are really best. The advice of the older teachers, those kings who as engineering authorities we reverence, is often times good, often times too conservative; so it must be mixed with the leaven of advice from the younger, more restless, and perhaps more progressive many, before there can be evolved the more perfect teacher, the most perfect method. To paraphrase Kipling,

> If you can talk with crowds, and find their virtues,
> Or walk with Kings—nor lose the *common touch,*
> Yours is Success.

BY J. A. L. WADDELL,

Consulting Engineer, Kansas City, Mo.

Through the urgent request of a member of the Committee I have been persuaded to discuss the subject of "Teaching Structural Design," although it is some thirty-three years since I left the field of pedagogy to enter that of consulting engineering practice. However, I feel that I am not altogether incompetent to treat this important matter, because I have had so many men working under me on design in all those years that I have been able to observe their shortcomings and to speculate upon how best to overcome the defects in their education.

In the first place, I believe that the rank and file of technical men—I mean the minor draftsmen, the surveyors, the inspectors, and others of that ilk—do not receive the right kind of training. A large proportion of them have risen from the ranks, having obtained their technical instruction in the school of hard knocks; while many of the remainder have had too much education of a type they are not fitted properly to acquire. Those who have received a more or less systematic training may be grouped into the following classes:

A. Those who have studied in trade schools or night schools or who have had a correspondence-school course.

B. "Flunk-outs" from the higher-grade technical schools.

C. Unambitious graduates of the last-mentioned institutions.

In my opinion, all of the men just described would have been greatly benefited by receiving a short, limited, thorough, practical course, scientifically adjusted to their needs as wage earners, so as quickly to make them capable of rendering effective service in minor capacities, and of earning at once enough to support them comfortably in a moderate style of living. Trade schools of a greatly improved type are what such men need to fit them for their unambitious careers; and later I shall indicate of what I deem their courses should consist; but, meanwhile, I desire to say a few words about the characteristics of the men in the above-mentioned groups.

First. The peripatetic draftsmen, surveyors, and inspectors, who have had no special education other than that of the "Three R's" or perhaps that of the high school.

Sometimes these men by industry manage to make good and even to graduate into a higher class of technical assistants, but the mass of them are unsatisfactory, unreliable, and disappointing. They are simply wage earners; and their ambition seems to be to secure as good compensation as they can for as small an amount of effective service as their employers are willing to accept. They work by the clock, and they require constant watching, not only to ensure their giving a proper *quid pro quo,* but also to prevent them from making serious mistakes in their work.

Second. Those who have studied in trade schools and night schools.

These often prove to be fairly useful assistants, but their limitations are quite restricted, and some of them at first have too exalted an opinion of the value and reliability of the education they have received.

Third. Those who have taken a correspondence course in engineering.

Most of these are very disappointing, for they think they possess knowledge which they do not. In my opinion, about the only real advantage in the correspondence school is that it makes some of its students pay attention to their technical book reading in a manner which they would not adopt when studying without help. Most individuals hate to spend money for something they do not receive, hence the correspondence-course student will generally study harder than the man who tries by his own unaided efforts to acquire technical knowledge from books.

Fourth. Flunk-outs from the higher technical schools.

Some of these manage to make good, but most of them develop only mediocre professional careers. Some of them failed to finish their course from lack of funds or because of illness and not for want of ability. Such men, though seriously handicapped, by reason of not possessing a diploma, as well as on account of insufficient scholastic training, often succeed quite well, and sometimes even reach to prominence. But those who failed from lack of ability or application, or who were expelled on account of wildness, or who were dropped because of having fallen into bad habits, seldom manage to do more than earn a bare living.

Fifth. Unambitious graduates.

Generally such men are plodders without employing much energy, perfectly reliable up to a certain point but not beyond, painstaking but not progressive, and unsafe to entrust with any work on which they are not experienced.

All such men as those above described are necessary in the conduct of engineering work; for in our profession, as well as in all other walks of life, there must always be "hewers of wood and drawers of water," and only a few can ever climb to, or even near, the top of the professional tree. Such mediocre men, however, should be made as truly proficient as their natural limitations will permit. Two or at most three years of training in a good trade school would give them a practical education which would prove invaluable; and it should be adjusted to the needs of the different callings which they desire to pursue.

The course should be one without "frills," everything taught being directly to the point and aimed to train quickly each man to earn a comfortable living. They do not need instruction in the humanities, foreign languages, economics, oratory, higher mathematics, advanced physics, chemistry, or technical mechanics; but they do require a thorough drilling in arithmetic, algebra, geometry, plane trigonometry, drafting, descriptive geometry, perspective, surveying, technical nomenclature, materials of construction, elementary physics and mechanics, and the rudiments of the English language. By the latter, I mean they should be able to spell correctly all ordinary words and the special technical ones that they are likely to use, and to prepare intelligible reports for the perusal of their immediate superiors, although not necessarily for publication. And while these subjects are being taught them, the instructors should impress upon their minds the importance and the practical application of all that they learn, so that they may be encouraged to neglect nothing in the pointedly practical and utilitarian course of instruction they are receiving.

The establishment of such trade schools would inevitably tend towards the raising of the average mentality and natural ability of the students in the higher engineering schools, and would militate materially for increased efficiency and greater accomplishment therein. This is mainly because when the course is adjusted for average minds it does not work well for either the very bright or the rather dull students, holding back the former and discouraging the latter. It is far better to grade technical students according to their capacity to receive instruction, throwing out ruthlessly the incapables and the over-slow plodders, and adjusting the higher course to the capacities of the brighter (but not the brightest) men in the classes.

If there be but four years allowed for giving such higher engineering courses, the instruction should be of a rather general nature, leaving the highest branches to be taken care of in post-graduate schools, the idea being to turn out at graduation men who are well trained in a broad way on all branches of engineering but not really expert in any, who have sound conceptions of life and citizenship, who are prepared to take quickly a prominent place in both social and business affairs, and who are capable of soon perfecting themselves in any class of professional work. This course should differ quite a little from the engineering courses given in this country to-day, mainly because its prime object would be mental culture of the highest type and the development of a capacity for right thinking and of keen conception, combined with a somewhat superficial practical knowledge of all the main branches of engineering—enough to enable the graduate to specialize speedily in any branch, and to avoid the danger of being found ignorant of practical things that he ought to know.

The post-graduate schools would provide an opportunity for any engineering graduate, desiring to continue his studies, to specialize in any line; and the course should be so thorough that the limit of current knowledge in any specialty could be reached by the students. For that reason all the courses should be given by specialists; and the feature of true economy in design and building should pervade all instruction. There need not be many such schools, for, probably, the attendance would not be large; but they should represent the highest possible attainment in technical teaching—the *ne plus ultra* of pedagogy.

With the system of schools herein described, our country would be provided with an army of well and practically trained subordinates for all lines of technical work, an adequate number of technicists fitted to act as officers for such subordinates and capable of advancing to any height in engineering, and a small body of the most thoroughly trained engineering specialists in the world. By means of such a combination our profession inevitably would progress with leaps and bounds; and the engineering constructions of the future would surpass those of to-day to the same extent that those of the last half century have surpassed those of all the previous ages.

This scheme of dividing students into groups according to their ability and ambition has been adversely criticized as being un-American and tending to establish a caste or aristocracy; but such criticism is without valid foundation—moreover, is it possible under any practicable conditions to prevent the existence of an aristocracy of brains? Substantial national progress should not be interfered with because of any pseudo-democratic notions like the one mentioned.

But, some of you may ask, what has all the preceding to do with the questions set by Professor Fuller and his co-workers concerning the teaching of structural engineering?

Certainly it has apparently no direct bearing thereon; but without such a preamble to make clear my belief as to what constitutes the most effective method of providing technical education for our future engineers, I should not be able properly to deal with the various questions propounded; consequently, I trust that all concerned will pardon my seeming irrelevancy.

Objects.

The main objects of the structural courses should be—

First. To give the student a practical knowledge concerning the general features of engineering structures, how they are manufactured, and how they are erected under various conditions.

Second. To teach him thoroughly the general principles of proportioning those structures which are of simple or ordinary type, paying sufficient attention to practical matters to enable him to undertake at once after graduation, of course under proper guidance, the designing work for such constructions.

Third. To give him also, if time permit, an elaborate course on the theory and practice in the designing of complicated and unusual structures, so as to start him well upon the road to becoming an expert in the line of such constructions. This is properly the function of the post-graduate schools, but it might be covered regularly in other engineering institutions giving a five-year course, or as post-graduate work supplementary to a four-year course.

Subject Matter.

Professor Morris is correct in his statement that "the major portion of the work in a civil engineering course should be of a fundamental character and required of all civil engineering students." The technical school is no place in which to specialize, because the student does not know what line he is best fitted for nor what work will prove to his taste. If he has the ambition to become a specialist, let him go into a general and varied practice for a few years after graduation, so as to determine what line is best for him to pursue, then take two years of special instruction in a post-graduate school.

As it is impossible to-day to pursue a large civil engineering practice without constantly running into mechanical and electrical engineering work, it is necessary for every broad-gauge, well-rounded, civil engineer to be posted on at least the elements of mechanical and electrical engineering. The civil engineer, however, does not often encounter mining engineering problems, hence the civil engineering student does not require special instruction in mining engineering. The converse of this, however, will not hold, because the mining engineer is constantly meeting with problems that pertain to civil engineering, hence his instruction should contain more than the mere elements in certain of the principal branches of civil engineering.

Again, mechanical and electrical engineering students need some instruction in civil engineering, but not to the extent that civil engineering students require to be taught mechanical and electrical engineering.

In the teaching of structural design, particular attention should be given to the features of economics and æsthetics in both the regular and the post-graduate courses. This statement cannot well be too forcibly made.

Every engineering student should be properly instructed in drafting, because any graduate engineer who is not a fairly good draftsman is likely at times deeply to regret his deficiency in this particular. Some young men have the idea that, if they learn to draft well, they are likely to be kept by their employers continually at drafting. While this tendency certainly exists, most assuredly the way to meet it is not through ignorance and incompetence.

The theory of reinforced-concrete design should be given in the regular course; and but little of it should be left for post-graduate instruction. The elements of steel-arch bridge designing and building should be taught in the regular course, but thorough training therein should be postponed for post-graduate instruction. This remark pertains also to movable spans, suspension bridges, and cantilevers.

In my opinion, a complete treatment of statically indeterminate stresses and secondary stresses should not be given in four-year courses, but should be left for the post-graduate school. These subjects require a great deal of time, which might better be spent on cultural and economic studies.

It does not pay to spend very much time on the study of stone-masonry structures, because reinforced-concrete structures have replaced them almost entirely; nevertheless the student should still be taught the theory of the masonry arch. Similarly, a short and elementary treatment of astronomy and geodesy might be given in the regular course, leaving a thorough study thereof for post-graduate work; because very few practicing engineers are concerned to any great extent with either astronomy or geodesy proper.

In respect to the study of languages, the members of the S. P. E. E. must be tired of hearing me preach—suffice it to say that I advocate cutting out entirely Latin, Greek, and German, making French optional and Spanish obligatory, and drilling thoroughly in English during every year of the curriculum, not failing to include practical instruction in the writing of contracts. My book on "Specifications and Contracts" was prepared specially for the use of technical students, and I believe that if it were employed as therein indicated, the graduating classes would have a fairly good knowledge of the intent in specification writing, and would be almost expert in the preparation of contracts.

Lack of space will not permit of my discussing any more of the fundamentals for engineering students enumerated by Professor Morris.

Manner of Presentation.

In respect to the manner of presentation of the subject matter of the structural courses, I shall make a few remarks concerning points in which I am specially interested, but shall not attempt to cover the whole ground or even to mention many matters of importance.

In the first place, I believe that too many subjects of a preparatory nature that *apparently* do not pertain to engineering (although assuredly necessary therefor) are crowded into the freshman and sophomore years, thus discouraging many students who desire to have substantial results constantly in sight as a reward for their efforts. Again, nearly all our technical graduates are painfully ignorant concerning many important practical facts in engineering; and they even do not know the meaning of common technical terms or the names of the principal parts of engineering constructions. To obviate these shortcomings, I advocate giving to the freshmen, and to the sophomores (if there be not enough time in the freshman year), short preliminary courses in all subjects dealing with structures, so as to teach them the names of all the principal parts thereof (including the most important details), the characteristics of the materials that enter into the construction, the methods of manufacture, and the different ways of erection to meet various governing conditions. This would require for each course a ''Glossary of Terms,'' and would necessitate a few trips to inspect steel-manufacturing shops and engineering works under construction. The instructor should prepare, on an ample scale, isometric drawings of the various engineering structures, writing along each principal part its name or designation. During even this preliminary course, attention should be given to the matter of economics so as to accustom the students at the outset duly to consider this most important feature of design; and, if occasion offer, the matter of æsthetics, or the lack thereof, should be brought to their attention. By mixing this practical instruction with their mathematics and other non-technical studies, the interest of the students in real engineering work would be aroused, and the entailed diversity of thought would make the course more agreeable and satisfactory.

While I believe in teaching the wheel-load method of finding stresses and moments, I should always explain that it is very seldom used in actual practice, but that the equivalent-uniform-load method is employed instead. Again, in finding stresses in steel arches, I would teach both the influence-lines method and the old-established method of unit panel-loadings.

As for the matter of giving individual problems to students for solution, I greatly favor it—notwithstanding the fact that it may take a great deal of their time—for the reason that nothing so well impresses any theory upon a young man's mind as does applying that theory to the solution of an actual problem in design or construction. Incidentally, I might recall to the minds of some of the members of the S. P. E. E. the fact that two years ago I prepared a series of examples to illustrate the methods given in my "Bridge Engineering" for making quick computations of the approximate quantities of materials in bridges and trestles of all kinds. While a number of students in several technical schools agreed to enter the competition (for which I offered some nominal prizes), they all withdrew on account of our country having entered the European war. I am still of the opinion that the solution of that series of problems would prove of great benefit to the better class of students in structural engineering (especially those taking post-graduate work), if only for the reason that it would show them the practicability of making exceedingly-quick and fairly-accurate estimates of cost for proposed bridges of all types.

Training of Instructors.

To the list of five essential qualifications of a good teacher of structural engineering, as given by Professor J. Hammond Smith, I would add the following:

6. He must have had sufficient practical training, in all the branches which he teaches, to understand thoroughly the application of the theory to practice, and to make evident to all concerned (especially his students) that he is truly a master of his subject.

7. He must be so interested in the welfare and advancement of the engineering profession that his students will quickly become interested therein also.

8. He should be fairly well posted on the economics of all the subjects he teaches, and should dwell constantly upon this important feature of design when imparting instruction.

9. He should be so interested in ethics and equity as to in-

spire in his students correct ideas concerning these fundamental essentials for the greatest professional success.

Professor Smith's method of teaching structural engineering by combined lectures, recitations, and quizzes is the best possible way of imparting knowledge. I used it over thirty years ago; and it worked to perfection. In addition, I acted as consulting or advisory engineer to my classes; and this method of teaching proved to be eminently successful.

Much more might be said about the qualifications of instructors in structural engineering, but this discussion of mine, I fear, has already exceeded a reasonable limit. Before concluding, however, I desire to call attention to a most reprehensible practice that is altogether too common in technical schools, viz., taking men out of the graduating class and immediately making them instructors. The objections to such a custom are as follows:

First. No one should be allowed to teach any branch of engineering until he has had at the very least three years of real practical experience, not only because without practical knowledge one is absolutely unfit to instruct others in technics, but also because the students will not have a proper respect for a teacher when they know him to be merely a theorist.

Second. Inbreeding in the faculty of any institution of learning is not conducive to the highest type of development, tending, as it must, to the continuance of faulty methods and acting as a deterrent to healthy progress.

Third. It is difficult, if not altogether impracticable, for a young instructor to maintain proper order and to ensure for himself due respect when teaching students with whom for two or three years he has been on the most intimate terms.

Fourth. A recent graduate is, of necessity, rather narrow-gauge; and he cannot have the broad vision requisite for inculcating in his students either a love for the profession or the lofty ideals that are essential to true success.

DISCUSSION OF REPORT OF COMMITTEE NO. 15.

BY HALBERT P. GILLETTE,

Editor, *Engineering and Contracting.*

The writer is in full accord with Mr. Henry J. Burt's outline of the objects of structural courses. Particularly should emphasis be placed upon his statement that "it devolves on the teachers not only to prescribe the studies to be pursued during the college period, but to so train the student that he will continue in a progressive channel" after graduation.

As an editor of a civil engineering periodical, the writer has long been impressed by the fact that a large percentage of civil engineers do relatively little reading of any engineering periodicals. Whenever the writer goes to the library of an engineering society he notes what a pitifully small number of men are usually studying either periodicals or books. When he talks with practicing engineers, he finds that most of them excuse their ignorance as to recent developments in engineering, design and construction on the ground that they have been "too busy to keep up with the literature of the subject." When he sees that the total subscription lists of all the civil engineering and contracting periodicals combined do not include more than half the possible subscribers he is astounded.

The bald fact is that the majority of civil engineers cease to be real students of civil engineering shortly after they graduate. This being so (and sixteen years editorial experience on the two leading civil periodicals has shown the writer that it is so) there are but two explanations of the conditions: (1) That civil engineering periodicals do not publish usable facts, or (2) that most civil engineers have neither recognized the necessity of continuous study nor formed the habit of constantly searching for new information.

The first of these alternatives can be dismissed without argument, for nearly every recent civil engineering book is full of references to, and quotations from, articles that have appeared in civil engineering periodicals. Evidently the most studious of civil engineers—the authors of engineering treatises—find the contents of civil engineering periodicals worth while.

The other alternative therefore seems inescapable. Of course, it may be said that the non-readers among civil engineers are those who have never gone to engineering colleges. The writer's observation gives no support to such an assumption. Indeed he has usually found that the man who has been able to train himself to be a civil engineer without the aid of an engineering college is usually more of a student of engineering books and periodicals than is the graduate of such a college. His struggle to make an engineer of himself has developed in him not only facility in searching for knowledge, but has founded in him belief in the value of such searching. *Finally, it has habituated him to be a searcher for knowledge.*

On the other hand our present courses in engineering often tend to atrophy the instinct of exploration. The teacher does the exploring, and presents to the student the results in a form readily assimilated. During four of the most formative years of life, the engineering college student is not made to search for and analyze data.

The late Professor Henry James, in his "Talks to Teachers on Psychology," says that he believes most men form nearly all their habits before they are twenty-five years old. The writer believes this to be a fact. Granted that it is, how pitifully weak becomes the argument that engineering students need not be trained in searching for data because that is a training that they will naturally impose upon themselves after graduation.

The writer fears that in the desire to teach students the "principles" of science and engineering, a great error is being made by many teachers. Principles, it is true, should be taught. But without a great store of details in one's mind, or readily accessible, principles can not be put to the best use in practice. In fact a strong argument can be advanced in favor of the proposition that principles should be taught only after many details of practice have been learned. Certainly, the greatest thinkers have been the men who have first acquired detailed knowledge and from the details have themselves derived the principles.

Reversing this process makes matters easy for the teacher and easy for the student; but does it not lead to the student's becoming perpetual nestlings, waiting like young robins for worms to be brought to them? Instinct saves the young robins from an everlasting life of being fed, but there seems to be no searching instinct that leads the average man to hunt for knowledge. The habit of searching must be trained into him.

The teaching of "principles" has become almost a fetish in America. What is a principle that entitles it to so much reverence? A principle is merely a law that expresses a factor common to many individuals or classes of facts. A knowledge of principles therefore greatly reduces the strain upon the memory and facilitates the operation of the mind. But known scientific principles are countless in number, and they are daily increasing by the hundreds. It is beyond the power of any human mind to memorize more than a small fraction of all the scientific principles now in print. True, some principles are of wide scope and others are narrow; but if the teaching of principles is to be the prime object, well may it be asked where the line is to be drawn.

More and more it grows upon the writer that the formation of habits to be pursued in after life should be the prime object of teachers. Students can certainly not be taught many details, nor in fact can they be taught many principles, relatively speaking. But they can be taught how and where to search for information, how to classify and organize the knowledge thus acquired, and how to go about to apply the knowledge.

Mr. Burt puts it very well when he says that one of the purposes of training is "To develop in the mind the powers of analysis, synthesis, observation, imagination and logic, so that the man will always be a student." The writer is glad to see mention made of "logic." There are few engineering colleges that require the study of logic as a formal course. Unfortunately there is no very satisfactory text book on logic. Perhaps Bain's is the best one for class purposes. Some teachers prefer Jevons. But there is no doubt that the study of formal logic is very useful as a training in the use of words as tools for reasoning. Less can be said of existing books on logic as aids in inductive reasoning. No logic whatever discusses inventive or imaginative reasoning. Hence teachers of logic must themselves go beyond the covers of the text books on logic if they are to arouse deep interest in the truly fascinating science of systematic thinking.

It may serve to bring out more specialized discussions of structural engineering if the term structural engineering be first defined. The writer was recently asked by the Illinois Structural Engineers' Association to assist in defining structural engineering. The accompanying editorial from *Engineering and Contracting*, December 25, 1918, contains the writer's contribution to this question.

WHO IS A STRUCTURAL ENGINEER?

The Illinois Structural Engineers' Association has asked the editor's assistance in framing a definition of Structural Engineer. The first step involves defining engineering.

An editorial entitled "Who Is an Engineer?" appeared in our issue of December 4, and we there gave the following answer: An engineer is one whose vocation is the systematic study of science and the application thereof to problems of economic production.

In this definition the word "production" is to be used in its broadest economic sense. It even includes the effects produced by the military engineer; for while military engineering has for its ultimate object the defeat of an enemy, the attainment of that object is best assured by the application of science in an economic manner.

What is a structure? The following definitions are given in the leading American dictionaries:

Structure: That which is built or constructed; an edifice or building of any kind; in the widest sense, any production or piece of work artificially built up, or composed of parts joined together in some definite manner.—The Century Dictionary.

Structure: A combination of related parts, as a machine, a building or a bridge.—The Standard Dictionary.

Structure: Something constructed or built, as a building, a dam, a bridge; especially a building of some size, an edifice.—Webster's Dictionary.

Structural engineering includes the design and erection of modern large structures.—Webster's Dictionary.

None of these definitions will meet the approval of structural engineers. A structural engineer does not ordinarily design machinery, yet the Standard Dictionary definition specifically includes a machine, and the other two definitions do not exclude machines from structures.

"A piece of work artificially built up or composed of parts joined together in some definite manner" is a definition that seems to include all engineering structures, but it also includes things that no engineer would characterize as a structure. A lady's hat would fall within this definition.

Before considering both what must be included and excluded from a specification of the word "structure," let us examine three definitions of Structural Engineering, each to be found under the head of Engineering:

Structural engineering, the designing and erection of large buildings, great bridges and the like, especially those of steel.—The Standard Dictionary.

Structural engineering, the construction of bridges, aqueducts, foundations, steel frames for buildings, etc.—Professor George F. Swain in Encyclopedia Americana.

Professor Swain's definition is defective in that it merely names a few types of structures and ends with an "etc." that leaves full scope to the imagination—it does not specify. The other two definitions specify "large" structures. But what is large? And why limit structural engineering to large projects? None of the three definitions excludes contractors that are not engineers.

At the outset it should be recognized that every definition of structural engineering must be somewhat arbitrary.

The structural designer is necessarily an adept in the science of strains and stresses as applied to framed works, such as buildings and truss bridges; but his vocation does not limit him to framed structures. He may be called upon to design a concrete arch bridge, or a masonry retaining wall, neither of which is "framed," in the ordinary meaning of the word. Yet in designing either a concrete arch or a retaining wall, the science of strains and stresses must be applied. Indeed, we can not think of any class of structural engineering design that does not involve extensive application of the science of strains and stresses, whereas that science plays a relatively minor part in many other branches of civil engineering. Therefore, it seems desirable to give prominence to the application of the science of elastic deformation of solids as one of the functions of the structural engineer. The word structure must be given a rather arbitrary significance if we are to exclude from structural engineering all kinds of work that fall within other classes of engineering. We must exclude earth dikes and reservoir embankments, sewers and water mains, for such "structures" are usually designed by hydraulic engineers. We must exclude engines, boilers, electric generators, electric transmission lines, and many other "structures," because they are usually designed by mechanical and electrical engineers. In fact, such a great variety of "structures" must be excluded that it becomes a hopeless task to specify in general terms that are not too general just what a structural engineering structure is.

Any attempt to define a structural engineering structure by merely enumerating the types of structures, such as buildings, bridges, etc., is not only unscientific but subject to change as new types come to be regarded as structural engineering structures.

A broad definition may be framed thus:

A *structural engineer* is an engineer who specializes in the application of the science of strains and stresses and in the economic use of labor and materials incident thereto.

In defense of this definition it can be said that while it does not draw a sharply defined line between structural engineers and other engineers, there is, in fact, no sharp line of demarkation. Also it may be pointed out that no other class of engineers specializes in strains and stresses and the economic problems associated therewith. The hydraulic engineer, for example, should understand the principles of elastic deformation, the strengths of materials, etc., but he certainly need not be as deeply learned in these matters as is the structural engineer; and, conversely, the structural engineer need not be as skilled in the theory and economics in hydraulics as is the hydraulic engineer.

A structural engineer is primarily an engineer, or one who systematically applies science in an economic manner; but his specialty is the design and construction of those types of structures in which a knowledge of strains and stresses and the properties of materials is of paramount importance.

BY GUSTAV LINDENTHAL,

Consulting Engineer, New York City.

The report of the Committee appears to deal with methods of teaching, which concern teachers more than practicing engineers.

We know there is an undersupply of skilled structural draftsmen and an over supply of poor ones. The fault seems to be at the schools in tolerating poor drafting and handwriting. Caligraphy as such I believe is not taught at all. Most technical students are slovenly draftsmen without sufficient knowledge of descriptive geometry or of perspective or of the technique of making neat drawings. They seem to believe that kind of work beneath serious application. Yet a useful engineer must grow up from the ranks. He must be a first class, speedy and neat draftsman. Then only can he be entrusted with detailing and designing, with computations, analysis and interpretation of specifications. Then follows the more important work in the office and shop and field. A chief engineer who has not worked himself up in that way is lacking in essential practical training and qualifications although he may have acquired thorough theoretical training. Most students are kept at school too long. The sorting out should commence with the fourteenth year. Dunces even if they be of wealthy parents should not be allowed to enter the higher classes where they act as a brake upon the progress of those mentally better qualified. Each successive year there should be a severe culling out so that only those students should be allowed to remain after their twentieth year as are worth educating for the higher branches of engineering.

All of them should be taught from the start the necessity of learning the art of self-support and earning their board unless they are so exceptionally qualified as to make it worth while for others to bear the expense of their education after they have become of age. Boys sorted out when fourteen to eighteen years old should learn trades and become mechanics, not in vocational day schools amid refined surroundings (paid for by the tax-payer), learning masonry perhaps by handling nicely varnished wooden bricks or running a lathe or other tools in elegant laboratories, but by actual fruitful work as apprentices and helpers to older and experienced mechanics in the shop, at the wall, in the quarry and mine, etc. There will be among them always some having more aptitude and ambition than others. Let these go to educational schools in the evening, there to acquire the theory of their various trades and thus become, each in his own line, a truly accomplished mechanic and worker. From their ranks we get our foremen, superintendents and practical managers. We are very short in this country of good mechanics (plumbers, masons, carpenters, stone cutters, building trades), all commanding high wages, but we are long on high school and college boys who think themselves too good for trades and are wondering why they get only about half as much wages as a good mechanic and laborer. The fault is with our pedagogues inculcating wrong ideals.

Read the history of the early English, French and German engineers. How scant was the theoretical foundation they could obtain in their youth and how they succeeded only through hard work in making the most of their personal endowments. About 90 per cent. of present-day engineering is imitative; about 8 per cent. only is more or less progressive and only 2 per cent. original and creative.

Much of the scientific ground work for certain engineering branches can be acquired by young men before they are twenty years old. After that age their time is better employed in actual practical work. All engineers cannot become chief engineers, just as graduates of West Point cannot all become generals.

Take highway engineering. We will have to build and maintain in the United States about two million miles of highways. That will require at least 40,000 engineers of various grades year in and year out. Is it necessary that this kind of engineer should spend his time at college until he is twenty-two to twenty-four years old?

My views on engineering education are at variance with those so readily accepted by the majority. I appreciate and value the efforts made by teachers to improve and advance the art of teaching, but I am unable to fall in with some of the views advanced in the reports.

I regret that I cannot spare time to enlarge on the subject of your own report as I should like to do.

BY O. H. BASQUIN,

Professor of Applied Mechanics, Northwestern University, Evanston, Ill.

Mr. Burt's proposition that "the welfare of the commonwealth has first claim to consideration in the objects to be attained" appears to me to be satisfactory for state institutions;

for other institutions I suspect that the welfare of the student should be regarded first. If this is not the policy of the institution it seems that this attitude should be made perfectly clear to the student.

Professor Smith's paper, according to its title, relates to the training of instructors; the matter presented appears to me to relate almost exclusively to the qualifications of an instructor and how he should teach.

The first qualification presented has a distinctly Prussian flavor: "He must have a commanding bearing in relation to his classes." Again: "The teacher must be in full command in his classroom, at all sessions, whether they be lectures, recitations or design periods." This reminds one of the stories that were told of the pioneer school teacher whose first duty was to show the big boys that he could lick them, singly or in groups. I like better the third qualification given for an instructor: "He must be able to inspire and lead his students," and if one has this ability to inspire, I do not see the necessity for the forbidding mien.

One of the hobbies that I have been harping on for some time is that we ought to have a book written on "How to Teach College Men." If one wants to become informed on any science, to practice any art or trade, or even to play a game, he can generally find a book which will tell him much that he wants to know upon that particular topic. If he wants to become a college teacher, where should he go to find the instructions? So far as I know, he must read papers on particular phases of teaching, papers which do not reveal the general principles of teaching, and many of which appear to advocate conflicting views.

The principles of teaching have been formulated for teachers of secondary schools. Apparently these principles should be somewhat extended for college teaching, since our objects are somewhat different, and our pupils are certainly different. But so long as these remain the only books upon the subject, I suspect that college istructors should become familiar with them. Teaching is applied psychology, in one of its phases, and I think a teacher will do well to become familiar with the psychology of learning and undertake to have a sound basis for the methods of teaching that he employs.

BY S. C. HOLLISTER.

The committee, in making its progress report at the 1918 meeting of the Society, divided its attack on the subject assigned to it, ''Methods and Details of Teaching Structural Designs,'' into four parts, as follows: (1) The *objects* of structural courses; (2) the *subject matter* necessary to carry out these objects; (3) the *manner of presentation* of the subject matter; (4) the *training of instructors* to carry this out in an effective manner. Papers were then offered upon these parts, each prepared by a member of the committee.

The writer finds it difficult to present his discussion of this report without presenting, also, a statement of his viewpoint of the fundamentals of an engineering education. It would seem necessary to discuss engineering education in order to maintain a proper perspective of structural engineering curricula, both as to objects and subject matter; and to discuss engineering educational methods in general as well as the methods to be employed in the teaching of structural courses. Back of all of this lies the consideration of a change in engineering curricula in general in order to meet the new conditions which have been brought suddenly to a climax by the world war. It would seem to the writer that too little attention has been given in the report to this broader aspect of the fundamental objects of engineering education and their relation to the field of the engineer of to-day and the near future.

The object of any educational process is to awaken the spirit. It gives rise to perception, perspective, and methodical observation and thought; and arouses in the individual interest and ambition. It is dynamic and deals more with the relationship of accumulated facts than with the retention of facts for their intrinsic value. Such a process is the foundation of a profession.

The object of an engineering education is to awaken in the individual his responsibility as an individual in political, economic and business relation with his fellows; to awaken in him consciousness of scientific fact, and the spirit of research and application of that fact; and lastly, to arouse him to convey, on broad, unbiased principles, his field of science into the practical world as a service to his fellows.

Some may say that such a conception of an engineering education is distinctly idealistic and not practical. It is as necessary to instil in the individual the spirit of a life of service through his professional activities as it is to supply him with the details of the practical phases of his work. It is this idealistic inspiration back of his daily routine duties that projects this individual with enthusiasm along a course of service. It is the living thing in his practiced profession. It is, therefore, as necessary to him as in his fund of technical information, and is as practical as living itself.

If one were to question students entering college as to their reasons for the selection of a course in engineering, the result would disclose, for the most part, superficial, immature, or even obligatory objectives. This is the result of the lack of a common conception of the field of the engineer. Again, if one were to ask the student about to graduate from an engineering course, for his idea of the engineering profession, the answer would indicate for the most part, a largely technical viewpoint of the activities of the engineer. This second answer is significant of the technically biased viewpoint resulting from the curricula in current use. Both deficiencies could be corrected by the readjustment of the activities of the engineering institutions. The second is perhaps the most vital since it is a measure of the product of the institution, and is therefore an indication of the objective of the average engineering educational system.

The engineer is entering upon a new era of usefulness in public and civic service. The problems before the nation to-day depend in a large degree upon the services of the engineer for their solution. His professional outlook has rapidly broadened, and with it has grown the necessity for application to other than the technical phases of his activity. The development has placed the engineer in a new relation with society and its very nature makes it a permanent one. An era has come when the engineer may take a position in society commensurate with the importance of the service he renders.

This change in the scope of the engineer's activities opens a field for researchful study on the part of engineering institutions as to the objectives to be attained in the near future in the engineering curricula. A study of the form of service which the engineer will be called upon to render will offer valuable suggestions as to the material to be presented in an engineering course.

It would seem that the present curriculum lacks particularly in arousing the engineer student to those phases of his practice which are not of a technical or scientific nature. He should be well grounded in the fundamentals of economic and business relations; and his course should include a fundamental study of economics, economic history, business law, corporations, banking, finance, labor problems and their history,—in short, it should set up a fundamental basis to arouse interest along the line upon which engineers of to-day and to-morrow are obliged to meet the business world. It is understood that it is not practical in any phase of this fundamental study to attempt to train the student in business details. What he should be furnished is the background upon which he may accumulate, as he progresses, the details of the work in which he is engaged.

In keeping with this larger scope of study, there are several phases of structural engineering study which might well be extended. All structural engineering is founded upon the mechanics of engineering and upon the theory of elasticity. This second subject is seldom brought to the attention of the average engineering student as such. Yet all important structures must be considered from this viewpoint and the necessity for this consideration is rapidly broadening in extent with the growth of the modern monolithic structures. A student should be left with the most important methods of the theory of elastic structures as methods rather than as solutions for certain structures. He should have a perspective of theory that he may group structures and applications and establish proper limitations. He should be taught advanced mechanics, differential equations, if possible, and the fundamentals of advanced theories of elasticity. Text books should be used throughout which aim at such a treatment of the subject and no books should be used which just embrace the boundaries of the course.

Another distinct revision necessary in the engineering curriculum, in the opinion of the writer, is a more careful and more thorough study of English. This should be undertaken to the exclusion if need be of the study of a foreign language. The relative importance of one's own tongue and of a foreign language leaves little vindication for the partial exclusion of English from the curriculum for the purpose of obtaining an embryonic knowledge of a foreign tongue. Exclusion of the mental training involved in teaching the subject, the reason for a foreign language in the curriculum is usually explained in two ways: it may be offered to furnish the student with the basis for the development of a reading knowledge of a given language; or it may give him the basis for the development of a speaking knowledge of a given tongue. Whereas it is a decided convenience that the student gain a reading or speaking knowledge of some language other than his own, it is far better that the student take the subject as an elective, thus supplying the necessary interest to make the course a dynamic subject rather than a storehouse of latent information. The theory advanced by some that the engineering student should obtain a reading knowledge of some foreign language to make it possible for him to carry on further study in his profession in that language is but a poor excuse for, in another sense, it may be taken as an acknowledgement of the fact that there is certain information which the student sometimes should have and that, rather than bring this information to him, it is undertaken to equip him with the basis for developing a reading knowledge of the language in the hope that some day he may run across this important work. In few other subjects in civil engineering does one find as large and important a fund of information in foreign languages which are not available in his own tongue as in the structural subjects. Though acknowledging this, it is the opinion of the writer that it is the duty of the engineering institution to collect and present this information to the student rather than equip the student with the various foreign languages so that he may seek those things out. Particularly is it emphasized that under no circumstances should the teaching of English in conjunction with structural engineering be minimized for the sake of introducing a foreign language.

It is appreciated that the courses now offered by engineering institutions have no room for this additional fundamental study. The engineering curriculum as presented in the past has offered little else than technical or scientific subjects. The engineering student has been held close to this viewpoint of the profession by such a treatment.

It must be acknowledged that there are certain distinct classes of engineers and so-called engineers; but it is believed proper, in framing an engineering curriculum, to aim directly at the higher type of engineering rather than to aim directly at the lower type of engineering appending thereto possible additional training that might develop the higher type of man. The engineering curriculum as now framed does not countenance and thereby does not encourage the broadening of a student's education by including in his course the vital subjects noted above.

It is suggested that a five- or six-year course might well be arranged, the first four years of which would lead to a preliminary degree in engineering and would be considered as a pre-engineering course. It would include many of the allied subjects suggested above as well as the elementary subjects in engineering training. At the end of the four years, the student would then have practically completed his mathematics, would have a general knowledge of surveying, of mechanical drawing and of some other elementary engineering subjects, as, for instance, a large share of engineering mechanics, statically determinate structures, railway and highway location and hydraulics. Whereas, perhaps, he would not have received an engineering education, he would, if the necessity arose, be sufficiently equipped to fill a moderately remunerative position in some mediocre branch of engineering practice.

The additional two years would continue the work of the first four years of the course and would include developmentally the most important engineering subjects of the curriculum and the most vital of the allied subjects pointed out above.

The chief essential of any educator, whether engineering or otherwise, is of necessity the ability of that instructor actually to convey to the student the objectives intended in the course. Naturally this implies that he must be well informed concerning the subject which he is teaching; but it further implies the manner in which he shall present this subject and the manner in which he shall lead his students. The treatment of the subject presented by him should be dynamic; and any instructor at any time, presenting his course toward the student as a latent thing, should be considered no longer to qualify as an educator.

The instructor should awaken in the individual the spirit of his profession and the spirit of the course as a part of that profession. If he fails to do this, he has not been successful. He must measure his efforts by the results obtained on the average student, which includes the majority of his class. If he succeeds in arousing a wholesome interest in the subject which he has presented, he need not give thought to discipline. Not only will he be able to maintain the proper decorum in the classroom but he will be able to obtain from his students the requisite application to study. Many theories of teaching have been worked out in great detail, but these theories, practiced as such, fall down since only that teacher who is a dynamic force can bring the student into the spirit of his work, a duty when accomplished forming, in a large measure, the success of the instructor as an educator.

BY EDWARD GODFREY,

Pittsburgh, Pa.

Instruction in the details of structural design, from results that crop out in practice, in the experience and observation of the present writer, in his judgment, is in need of radical realignment. A number of diverse sets of facts that are the basis of the statement in the foregoing sentence will be given.

Some years ago I examined the detail drawings of two theaters which had been made by an engineering concern. The errors in details were so numerous that I did not count them. I classified them instead. There were twenty-two different kinds. Some of them were repeated many times. A number of them were so serious that they might have resulted in collapse of parts of the structure. I wrote these up for the benefit of the profession, and the article was published in *Engineering and Contracting*, December 8, 1915. Previous to this time I had written up a description of a large collection of errors in structural details from different plans that I had examined.* Some of these errors were similar in character to the others, showing the same disregard for fundamental principles of stability.

Now, it is of no particular significance that an individual, though holding himself out to be a structural engineer, should make blunders and errors. It is significant, however, that this engineer was unable to see that there was anything wrong with his details, though the builder, a contractor with no engineering training except the horse sense that his experience as a contractor gave him, could see all of my points and insisted, even at much expense to himself, upon everything being made as I dictated.

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* *Engineering News*, April 11, 1907.

The reader is referred to the published articles to see for himself whether or not the details were faulty.

But the most significant thing of all is that I was in a position where I could refer to no authority to sustain my points and to no writing except my own.

In engineering works and in the engineering class a structure seems to be a highly theoretical thing made of perfectly elastic substances that are subject to certain inexorable laws and obey those laws implicitly. But standing supreme over all of these laws is the professional judgment of the designing engineer, which ultimately sustains the loads. In my opinion the professional judgment of the designing engineer is worth practically nothing, unless he can amply sustain it by arguments that will stand the light of day and show that he has plain horse sense as well as some theoretical knowledge. In my opinion the theory of least work, and of redundant stress, and of the elastic behavior of concrete arches, and of secondary stresses due to such causes as the rotation of members on pins due to truss deflection, and most column theories, and several other nice theories, have a value only a little greater than that already ascribed to bald professional judgment.

To come right to the point, there is entirely too much theory, and there are entirely too many theories in engineering works and college teaching and not enough ordinary horse sense.

I could write a book on this subject, showing where engineers, among them some of the highest standing, have designed and discussed structures with their heads away up in the rarefied air of pure theory, while the details, that a man with scarcely any theoretical training could see were faulty, never came into their view nor concern. A few of the high spots will be touched.

When the Quebec bridge was first erected, it was put up with a great traveler as large as a 16-story steel office building. It consisted of two side bents 217 feet high. Now horse sense tells us (though books and theory say little) that two bents of this height ought to be braced together to prevent their swaying to one side and flopping down, especially if one million pounds of weight rests on top of the bents. Did the engineers provide this bracing? No. Well, what happened? Why the two bents did tilt over, with their million-pound burden, and pulled the completed bridge over, killing about 80 men. Did the Royal Commission investigating the wreck give due warning to the profession against the recurrence of another such blunder? *In eight pounds of dope issued by the said Royal Commission there is not a word about any such possibility.* There are some nice new theories, but so far as a discussion of the real cause of the failure is concerned this report is one of the greatest farces in engineering literature.

But the Quebec bridge was rebuilt. A well-braced traveler was employed. I had publicly called attention to the blunder of the first and prophesied that in the rebuilding no such blunder would be made. Again the designing engineers had their heads in the rarefied air of pure theory and high-class problems—a la the most approved literature of engineering. Great problems were solved. The solutions do credit to the designers and to the men who handled and erected the steel. Again a detail was overlooked—a detail that it required horse sense to discover. A great load was to be lifted on a swinging support. The load was to be suspended from a long line of bars and jacked up to place. The lifting scheme was excellently worked out. But why was there a second wreck.

Makers of pails for paint suspend the pail on a bail attached as close to the top as the bail can conveniently be attached. These men know, without being able, perhaps, to tell the reason why, that if the bail is swung, say a half inch above the middle of the height of the pail, you may be able to lift the pail without its upsetting, but the chances are that it will upset and spill the paint. Now, in raising the great suspended span of the Quebec Bridge the ''bail'' was hinged the trifling distance of 2¾ inches above the ''center of the pail.'' The pail upset, after it had been lifted a few feet. Did the profession see this and publish the lesson broadcast so as to warn others. Look for yourself at current engineering publications for the few weeks following the diaster and see if you can find it. I did succeed in getting a letter published which pointed out the real cause of the wreck.*

The Orpheum Theater in New York failed completely and solely because of a monstrous curved girder of 74 feet of a span and 12 feet of an offset or versedsine, and this girder was carrying a heavy floor load. The only thing that supported this girder till its collapse was small beams that it was supposed to support. The girder flopped down and pulled with it the whole structure, just a few minutes after 200 workmen had left the building. A large and important part of engineering education is in the hands of engineering periodicals. Was the engineering profession ''educated'' in the accounts of this wreck? Hear the history. After about a year of investigation and delay a set of the most absurd and inane reports were published that I have ever had to read. No mention was made of the real cause of the wreck. I succeeded in getting in a statement of the cause in *Engineering and Contracting*, February 18, 1914.

What do the authorities say on the instability of curved girders? Find it, if you can. You will find some nice theories on circular girders and some applications of the same where they are totally inappropriate. Find a warning, if you can, against using a curved girder with simply supported ends. But in current engineering publications after this wreck here is what you will find—some fine spun theory on the dire effect of the twisting of a girder due to deflection of a cross girder that it supports. Bosh!

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* *Engineering and Contracting*, October 25, 1916.

Four hollow dams have failed because the pressure on the wetted side and the pressure of water beneath them was not adequately resisted by the small weight of concrete in the hollow dam. What do books on dams say of under pressure? If the word of these books is to be depended upon for information on this subject, under pressure did not exist until 1910, or, by majority vote, it does not exist at all. One book, published since 1910, emphasizes the existence of under pressure. Others do not even give it the recognition of mention. I believe that instructors have at last begun to emphasize under pressure. They ought to refuse to teach from any book that does not emphasize the necessity of designing for under pressure.

When the Stony Creek Dam, a hollow dam that failed, was rebuilt, the description of the work stated that the type of dam was in no way responsible for the failure. Yet in the rebuilding the type was changed in these important respects: it was securely anchored to a deep cut-off wall; a lot of concrete was added at the up-stream edge to give stability; a very extensive drainage system was added; and, most radical of all, the drainage system was housed in at great expense to keep it from freezing. When I, a member, attempted to discuss the matter and point out these facts in the *Proceedings of the American Society of Civil Engineers,* I was denied the privilege. This is a sample of the way engineers are being "educated."

There is enough written on the theory of the elastic arch as applied to reinforced concrete arches to fill several books. I have looked in vain for some recognition of one of the biggest single things in this design of an elastic reinforced concrete arch, namely the bending moment at the spring of the arch and provision for taking care of it. For the sake of saving a little concrete in the arch ring a highly theoretical method of design is employed, and the abutment is assumed to be absolutely fixed whether its mass is sufficient to warrant this assumption or not. This method of design is based on pure theory. The elastic theory stands or falls on this premise, namely, whether or not the deflection of a reinforced concrete beam can be calculated. The deflection of a simple reinforced concrete beam cannot even be closely approximated; hence the elastic theory has no real foundation to stand on.

The use of the simple equilibrium polygon in solving a reinforced concrete arch is so simple and so appropriate to the case that it is a puzzle to me why the elastic theory should ever be brought to bear on the problem.

In reinforced concrete theories are rampant. The rodded column is based, in its use, on theory almost solely. The rodded column is a shaft of plain concrete with a rod near each corner, the rods being stayed at intervals of a foot or so by wires. Sometimes there are more than four rods. Some times they are bad enough to have rods in the middle of the side of a rectangle ''stayed'' with a wire in the same plane. The only thing supporting the use of a rodded column besides pure theory is a lot of misleading tests—tests of columns perfectly centered in an almost perfect testing machine. This is worse than theory because it inspires more confidence. A column, to be a proper member of a structure, must be tough. The rodded column is anything but tough, but the testing machine does not discover this.

In a score or more of bad wrecks rodded columns have proven their utter unfitness as structural members by their failure to sustain their loads and by their behavior in the wrecks. Apart from this I know of only one test of reinforced concrete columns where the thing tested resembled an actual structure and really tested a rodded column in the way it is tested as a building column. This test is described in *Engineering Record,* September 30, 1905. Here four *rodded columns* carrying two girders and a slab *failed at about 300 lbs. per sq. in.*

The theory of the rodded column does not consider the deflection of the beams and girders connecting in a monolithic character to the columns, and the unknown eccentric stresses at the corners, and the tendency to spall on account of this eccentric stress and the shrinking of the concrete that compresses the steel and aids in this spalling. On the other hand the same class of theorists who thus ignore facts concerning concrete, a very brittle substance, will split the hair of a gnat in making up theories of secondary stresses in the heavy members of a steel structure. A steel column may have a tremendous unit stress at one corner, due to poor milling, and nothing may result except the peening of the metal. A rodded column having a corresponding condition, due to deflection of the beams, will be sure to spall and may fail and bring down the structure with it. These things are theory in one sense, but they are theory that recognizes facts and is not blind in spots. These facts are eminently common sense, and therefore it is hard to make an ingrained theoretical mind see them. Hence we have the common standards of design in reinforced concrete that are prepared and approved by two classes of men: one of these classes will accept anything that has some authoritative approval, so that it will enable them to compete with other forms of construction; the other class are laboratory investigators who cannot see any difference between an ideal laboratory experiment and a building and who make no attempt to simulate the laboratory experiment to the building.

The stirrup or short shear member in a reinforced concrete beam is another theoretical creation. Someone with a theoretical knowledge of a truss conceived the idea that stirrups or short shear members, so called, since they look like truss members on paper, can be considered as truss members. The resemblance does not extend beyond the drawing board, for truss members must have perfectly definite and full-strength connections to both top and bottom chords. Stirrups and short shear members have no such connection either to top or bottom chord or flange of a beam.

No engineer will attempt to explain how a stirrup acts to take its alleged stress nor to explain what takes the shear of a beam between two stirrups or short shear members. Engineers have ceased to discuss both rodded columns and stirrups. They are ashamed of the alleged arguments in favor of these discredited features of design. As proof of this I point to a discussion on these subjects that took place in February, 1915, when I was severely castigated in a meeting of the American Concrete Institute in Chicago. After much insistence on my part the remarks of my critics were written out (most of them) and I answered them. But the men who made the remarks were ashamed of the weakness of their arguments and had sufficient influence to prevent the publication of the discussion. I have been assured repeatedly in the last four years that the discussion would be published, though I have been convinced in my own mind from the start that these men would never let it be published.

I have a standing challenge with the engineering profession to discuss both rodded columns and stirrups and publicly declare the standards of design as regards both, and dependence upon the same, to be outrageous. But the engineer who will dare to risk his reputation by standing up publicly and alone for these absurdities has not yet arisen. In bunches and committees they will pass reports and frame codes that incorporate these false standards of design, but individuals fight shy of being held responsible for something that will not stand the light of common sense.

The reinforced concrete flat slab has given rise to some complex theories that are of no more use than discussions as to how many angels can stand on the point of a needle. The flat slab between two rows of columns is no better than a similar slab between two rows of beams and needs no more complex theories to discover its limitations, interested mathematical prestidigiteurs to the contrary notwithstanding. This simple criterion is the one that should govern both in the making of a formula for design and in tests. But the men who have made the formulas and the tests have ignored this.

About the only practical test on a flat slab building that was a critical test was that made on the Bell St. Warehouse.* This test failed. Investigators have tested interior spots but they fight shy of a row of bays on the outside of a building where no girder exists or a row of bays across a building from outside to outside.

The flat slab and the rodded column, where tested critically, have failed to meet the requirements of the design by which they were constructed.

Now the charge I wish to make against the educators of the structural engineering profession is that by failing either to defend or condemn these wreck-breeders they are failing in their duty. Too much time is given to theoretical discussions that lead nowhere and create false impression of security, and too little time is give to common-sense discussion of the obvious causes of all wrecks, which need no higher mathematics to understand.

The engineering profession is living in a fool's paradise of fine-spun theory, and when a wreck occurs from some simple cause, they spin more fine theory to cover up the real cause of the wreck.

What ought to be done is this: cut out a lot of fine theory or let it lie embalmed in the books where it was born, and give a course in common, horse-sense in the details of structural design. Let editors open their columns to a free discussion of the indefensible, the bad, the wreck-breeding features of design in reinforced concrete and steel structures and in dams.

I have written this at the request of the chairman of the Committee on Methods and Details of Teaching Structural Design. It is not written to advertise my books or writings. If there was any place else to which I could refer for material for a course such as I suggest I would gladly mention it. I have learned that the way to write books that will not sell is to say in them the things that others have not said and perhaps will not agree with. Any instructor who wishes material for a lecture course in horse sense in structural designing may be able to find these writings in some large library.

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* See *Engineering News,* January 29, 1916.

EDITORIAL.

The 1919 Meeting.—Judging from the inquiries received in regard to the 1919 meeting to be held at the Johns Hopkins University, Baltimore, Md., June 25–28, inclusive, this promises to be one of the largest meetings of the Society. Everyone is interested in the general topic of this meeting, namely, "What changes should be made in engineering education as a result of what we learned and experienced during the war." If you have any ideas on this subject, you should be present and take part in the discussion.

The Young Man and the Meeting.—The advance a young man makes in his profession is dependent to a large degree upon his acquaintance with men in that profession who are in a position to aid in his advancement. It is an important question which confronts the young man entering any profession, since promotions here must be obtained largely through personal knowledge which other men have of the young man's ability. The young engineering teacher should decide how he can best advance in his profession by increasing his acquaintance in the field of engineering education. There are two important ways to accomplish this, one through writing and publication of papers, and the other through attendance at meetings where the leaders of his profession will be found. This Society offers exceptional opportunities to the young teachers in both ways. Not only is he urged to write papers for publication in ENGINEERING EDUCATION, the bulletin of the Society, but also to be present at the annual meetings and take part in the discussion and present papers which in turn will be published in the Proceedings of the Society. It is in the publication of this Society that we look for the best that has been written or spoken in regard to engineering education. As a financial investment the young teacher can ill afford to miss attendance at these meetings.

REPORT OF AUDITING COMMITTEE.

New York, N. Y.,
February 14, 1919.

The undersigned members of the committee appointed to audit the accounts of Mr. Wm. O. Wiley, treasurer of the Society for the Promotion of Engineering Education for the fiscal year ending with the 1918 meeting, take pleasure in reporting as follows:

We have examined the vouchers, checked the entries, totals and balances and satisfied ourselves that the records are accurate and complete.

Yours respectfully,

Arthur H. Blanchard,
James S. Thompson,
Henry H. Norris,
Chairman.

THE TWENTY-SEVENTH ANNUAL MEETING OF THE SOCIETY.

The Council of the Society has voted to hold the 1919 meeting at The Johns Hopkins University, Baltimore, Md., June 25–28 inclusive. A location near Washington was decided upon at the Northwestern meeting because of the many vital questions that might be intimately connected with the men who are in government service. There are still a great many questions of policy which must be settled before the exact relation of engineering schools to the R. O. T. C. can be determined.

The Engineering School of The Johns Hopkins University is one of the more recently established schools and has many unique features which will prove of interest to visiting members. A visit to the Naval Academy at Annapolis where we are assured of a hearty welcome would prove both entertaining and instructive.

NOTES.

There will be a number of important questions to be discussed at the annual meeting such as the final report of the Joint Committee on Engineering Education, military training, use of psychological tests, production engineering, etc.

A Local Committee at The Johns Hopkins University has been appointed composed of the following members: J. B. Whitehead, Chairman, J. H. Bringhurst, A. G. Christie, L. A. Doggett, J. E. Greiner, M. W. Pullen, John Ridout, R. E. Root, J. B. Scarborough, Charles A. Styer, and C. J. Tilden.

NOTES.

President Hayford has appointed Dean W. E. Mott as the representative of the Society to serve as a member of the committee which the Commissioner of Education invited to confer with the specialist in commercial education in Washington, March 31, on the subject of commercial engineering.

The Secretary has received numerous requests for copies of the report of the Joint Committee on Engineering Education as prepared by Dr. C. R. Mann. Copies of this report may be secured by writing the Carnegie Foundation for the Advancement of Teaching, 576 Fifth Avenue, New York City.

There was outstanding in back dues on February 1, $6,130.84. This is practically the total income of one year. The officers of the Society are very desirous of collecting as much as possible of this amount in order that they may meet current bills. If your account is included in this amount, will you not send a check to the Treasurer, Mr. W. O. Wiley, 432 Fourth Avenue, New York City, in order that the Society may not only meet the current bills but also that it may do the work which it should during the period of reconstruction.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., MAY, 1919 No. 9

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THE COLLEGES AND THE WAR.

BY FRANK P. McKIBBEN,

South Bethlehem, Pa.

"If he deals plainly with you, it is for the love he bears you. If he were to flatter you, he would be like all the rest of the world, and you would have no one near to tell you the truth; and a worse thing cannot happen to any one, old or young."—Charles V to his son.

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COLLEGE TRAINING AND THE WAR.

It was with a feeling of wonderment that first I heard Mark Twain's "cauliflower is nothing but cabbage with a college education." The impression regarding the value of a college education conveyed by him in Pudd'nhead's calendar depends very materially on the relative positions held by cauliflower and cabbage in one's gastronomic scale. A fondness for cabbage and a distaste for cauliflower would lead one to conclude that collegiate training is undesirable. But any ambiguity concerning Mark Twain's real opinion is dissipated by reading the entire calendar, which is as follows: "Training is everything. The peach was once a bitter almond; cauliflower is nothing but cabbage with a college education."

To those who have labored diligently to place a college training on a high plane, to fill our boys with inspiration from work so well done that it can not be done better, to give them sound minds and morals in sound bodies, in brief, to those who have believed in education, the war has brought a decided sense of satisfaction. It has demonstrated the value of collegiate training. It has done more. By placing the stamp of approval on college men it has brought about an incentive for greater effort; and a just reward will come to that teacher or that student who not only sees in the remodeling and upbuilding of his college now taking place an opportunity of real service, but who also puts forth his mightiest appeal for good. It is no time to bemoan the loss of "the good old days before the war." It is a time for patience, clear thinking, and hard work. Never was there a time when Van Dyke's words were more inspiring than now:

> "Let me but do my work from day to day,
> In field or forest, at the desk or loom,
> In roaring market-place or tranquil room;
> Let me but find it in my heart to say,
> When vagrant wishes beckon me astray,
> This is my work; my blessing, not my doom."

Our graduates and our undergraduates have nobly responded to the call to arms. So great was the rush to join the colors that many of us felt for awhile that the entire structure which we have labored so diligently to build was on the verge of a collapse and that something more than a mere palliative was needed if the machinery for training men should continue to perform its function at a time when trained men were needed as never before. Not only in numbers were college men conspicuous in government service, but many positions of responsibility and trust were fitted by them, notably President Wilson, Generals Foch, Pershing and March, Secretary Baker, Mr. Hoover, and Professor Masaryk.

That college men were considered primarily as officer material was clearly shown by the large percentage of alumni and undergraduates who received commissions. Indeed, one has but to glance at service records of any important college to conclude that collegiate training improves those qualities recognized by the army and navy as essential to leadership.

Colleges Can be Improved.

Valuable though the colleges may be, they can and will be greatly improved. And now is the time to inaugurate the changes if any are to be made. Especially at this time do students, teachers and executives long for something better. Many of them have just returned from Christmas vacations preceded by months of such marvelous educational experiments as to make acceptable any stable, well-organized, well-operated system of training. No college faculty should let this wonderful opportunity slip from its grasp. Make the desirable changes now, as speedily as possible, and then hold to the chosen course with perseverance and determination to let no one alter the purpose of giving men a real education.

Our educational system is susceptible of improvement along the following lines: (1) Elimination of wasteful methods; (2) increasing self discipline and self instruction among students; (3) improving the status of the teaching corps, thus resurrecting, after a long death, the idea that education is or should be the main business of the college.

Elimination of Wasteful Methods.—Under this heading can be grouped the following: Consolidation of and coöperation between educational institutions; saving time; simplification and reduction in numbers of curricula. It is unfortunate that the war did not bring about the consolidation of colleges where union would result in more effectual use of men and equipment. If consolidation is not desirable, coöperation, consisting of an interchange of teachers or reciprocal use of equipment, often is possible and may result in a distinct saving of effort. And what is of equal or greater importance, coöperation resulting in interchange of teachers vitalizes the teacher, requires him to give better and more work, broadens his vision and his field of activity. The consolidation and coöperation of the Massachusetts Institute of Technology and Harvard University should be carried further. Similarly Carnegie Institute of Technology and the University of Pittsburgh, almost on opposite sides of the street could profit by consolidation or affiliation. Lehigh University, Lafayette College, Muhlenburg College, Moravian College, located as they are, could be as well operated, would have better men and equipment if they were one institution. Another of the numerous examples is the medical schools of Johns Hopkins University and the University of Maryland. And in the same city the Baltimore College of Dental Surgery and the dental department of the University of Maryland may profitably be consolidated. These are only a few of the possibilities.

At many colleges the elimination of some courses of study would be a step in the right direction. Differentiation has gone too far.

Saving a few months or a year of time for each of several hundred thousand students is no small economy. Most college courses are of four years' duration. How much of that time is utilized. How much wasted? Would three years properly applied give as good results as four have in the past? While I believe they can, it must be confessed that most college authorities think otherwise, for nearly all institutions of learning hold to four-year curricula. Nevertheless, several colleges now contemplate operating throughout the year in such a manner as to enable capable students to complete their work in three years, while other students take four. On the other hand, Sheffield Scientific School's recent move was to increase the course from three to four years. The ordinary four-year course consists of eight terms of seventeen weeks' duration, a total of one hundred and thirty-six weeks. A three-year course with nine terms, each of fifteen weeks, has a total of one hundred and thirty-five weeks of instruction. I thoroughly believe that as much good work can be accomplished in this three-year plan as in the old four-year plan, provided the number of subjects carried by the student at a time be decreased, home study increased, loss of time during the college year eliminated, and the physical welfare of every student carefully developed. The two reasons advanced against adopting an intensive three-year plan are: loss in students' earning power during summer; and possibility that students cannot sufficiently mature, and cannot assimilate the college course, in three years. Very few data on the earnings of students during summer recesses are available, but those shown in accompanying Table I indicate that at Lehigh University the civil engineering students worked an average of 1.6 months and earned $110.00 per man during the summer of 1912. Recently 220 students from the University of Minnesota earned an average of $90.00 each during one summer's college recess. If these sums earned at those two institutions be a fair average, it is readily seen that the total earnings during the three summer recesses of the four-year course are not equal to the cost of the additional year's tuition and living expenses required by the four-year plan.

As to the power of students to assimilate the work in three years, I *know* little, but judging from the thoroughness in which some engineering subjects are grasped by juniors in some colleges while seniors in other institutions fail generally to do as well in the same studies, I am of the opinion that this question of effectiveness is largely one of the teachers and discipline.

In connection with the inefficient use of time during a college year, let us consider the normal school year at an eastern university as an example of an institution where good standards of scholarship are maintained and where the amount of work demanded of teachers and students is on a par with other high-grade colleges. The school year includes 260 days, of which 37 are Sundays and 223 are working days. In these 223 working days there are 51 holidays, including the half holidays of Wednesday and Saturday afternoons of each week and the vacations at Thanksgiving, Christmas and Easter and other similar periods, during which exercises are suspended. Therefore, there are only 172 days in each year upon which college exercises are held. These 172 days constitute 77 per cent. of the available working time during the school year, and only 55 per cent. of the total working time of the calendar year. It can hardly be said that an institution is efficiently managed when it utilizes only 77 per cent. of its available working period, and certainly the equipment and plant cannot be used to greatest advantage if students are present only 55 per cent. of the available working days in the calendar year. This condition is duplicated at nearly all educational institutions. Clearly the colleges are not rendering their maximum service.

Self Discipline and Self Instruction.—The best discipline

TABLE I.

Earnings of Civil Engineering Students of Lehigh University During Summer of 1912.

	Seniors, Months.	Juniors, Months.	Sophomores, Months.	Totals, Months.
Kinds of work:				
Municipal engineering	3	$2\frac{1}{2}$	$9\frac{1}{4}$	$14\frac{3}{4}$
Machine shop	$2\frac{3}{4}$	—	$5\frac{1}{2}$	$8\frac{1}{4}$
Engineering office work	$13\frac{1}{3}$	$6\frac{1}{4}$	$4\frac{1}{2}$	$23\frac{1}{12}$
Non-engineering office work	3	5	$13\frac{1}{4}$	$21\frac{1}{4}$
Construction	$5\frac{1}{2}$	$8\frac{3}{4}$	$6\frac{1}{2}$	$20\frac{3}{4}$
Railroad engineering	$8\frac{1}{2}$	$15\frac{7}{12}$	6	$30\frac{1}{12}$
Surveying	$11\frac{11}{12}$	$3\frac{1}{2}$	$1\frac{1}{2}$	$16\frac{11}{12}$
Highway engineering	6	2	$6\frac{1}{2}$	$14\frac{1}{2}$
Hydraulic engineering	$2\frac{1}{4}$	—	—	$2\frac{1}{4}$
Farming	2	—	$5\frac{1}{2}$	$7\frac{1}{2}$
Barbering	2	—	—	2
Canvassing	—	—	1	1
Total number of months employed	$60\frac{1}{4}$	$43\frac{7}{12}$	$59\frac{1}{2}$	$163\frac{1}{3}$
Number of men reporting	41	27	30	98
Number of men reporting having worked	30	20	26	76
Average number of months employed for all men reporting	1.5	1.6	1.9	1.6
Average number of months employed	2.0	2.2	2.3	2.1
For students who worked:				
Total earnings for summer, not including traveling or other similar expenses	$3,524.03	$2,282.25	$2,566.80	$3,373.08
Average earnings per summer per man, not including traveling or other similar expenses	$ 117.46	$ 114.11	$ 98.72	$ 110.17
Total earnings for summer, including traveling and other similar expenses	$3,904.13	$2,412.40	$2,843.20	$9,159.73
Average earnings for summer per man, including traveling and other similar expenses	$ 130.14	$ 120.62	$ 109.35	$ 120.52
Average earnings per month per man, not including traveling and other similar expenses	$ 58.49	$ 53.07	$ 43.13	$ 51.36
Average earnings per month per man, including traveling and other similar expenses	$ 64.80	$ 56.11	$ 47.78	$ 56.20

This table does not include the graduating class of 1912.

and instruction a student receives is that which he gives himself. We speak of mental training as if it were something our instructors can serve to our boys on silver trays. It is merely acquiring the ability to think accurately for a reasonable period of time. And the student must acquire it by personal effort. It cannot be taught to him, although the capable teacher can lend encouragement, inspiration and guidance. As self-instruction is the best instruction, every student should spend much time in the quiet of his study, thinking out for himself the problems of class room and the greater ones of life. To learn to think is a great prize and he who acquires it gains much. The words inscribed on Portia's golden casket apply admirably, "Who chooseth me shall gain what many men desire." But this wonderfully valuable ability cannot be secured alone in the class, the laboratory or on the playground, as necessary as is the training received there. It must come from within the student himself.

If there is one phase of college life to-day which demands the earnest attention of trustees, faculties, students and alumni it is this matter of "home study," which is not now taken seriously. If this problem be solved the others will soon disappear. The solution lies in fewer subjects carried at a time, fewer "snap" courses, higher standards in the class work, and sound bodies. "I am for hard and strenuous work. I do not at all wish to make work slipshod and dilettante. I would raise the standards of simple education, and force boys to show that they are working honestly. I want energy and zeal above everything. But my honest belief is that you cannot get strenuous and zealous work unless you also have interest and belief in work." The quoted words are those of Benson, whose wonderful book, "From a College Window," should be on every teacher's desk and in his mind and heart. I wish a series of meetings could be arranged for our instructing corps where Benson's essays would be read and discussed. The reason that boys do not force themselves to acquire mental discipline in "home study" is because we teachers and you administrators do not demand it with high standards, and because we do not make our classes sufficiently interesting to inspire the boy to seek learning.

Imagine the effect produced on a class of students by a system which permits recitations of from five to ten minutes' duration, upon the completion of which the student who recites in this short time leaves the room even though the time assigned for the recitation by the college be one hour. Yet I have visited a well-known institution where this is common practice in at least two departments.

In nearly all schools too many social, athletic and other meetings are allowed to interfere with the main function. A professor recently confessed that he was not sure whether he was engaged in an educational institution or a country club. Although participation in social and athletic affairs is very desirable, indeed should be compulsory, it should be supervised and restricted. Some boys want to be ticket seller, audience, orchestra, actor and stage manager. Their desires should be restricted to a reasonable number of college activities; sufficient to develop the boy, but not to overload him. Other boys, self contained, sadly need the benefit that comes from playing on a ball team or managing some college function, but we have no system by which this type of boy is developed. We leave it to the boys. They either do nothing or overwork in non-scholastic activities. Any capable dean can devise a system of units which will afford a check on the overzealous, and an incentive to the backward boy. Compulsory but restricted participation in college social and athletic activities would be a great thing for college students. If colleges required every able-bodied student to learn at least one game fairly well—tennis, baseball, football, soccer, lacrosse, basket ball, track athletics, there would be less intercollegiate contests for the few and more games for the many. There would be more exercise and physical development by every man in college and less record-and-heart-breaking by a few. Such a system must be operated by the faculty, not by another part of the college organization, otherwise there will be divided responsibility and divided power; and this never works successfully.

Improving the Status of Teachers.—The man who has the ability and desire to teach should be a teacher. It is a noble calling. The reward is great; not so much perhaps in material things as in some other fields of activity, but in contact with young enthusiastic life which responds generously either to help or constructive criticism. We must appreciate the importance of doing our work thoroughly. A few things well done is the net result of most lives, even though active. If Verdi had written only the Miserere in "Il Trovatore" he would have added his share to the world's progress. Unselfish service is sooner or later recognized. Possibly the undergraduate may not realize what is being done for him. But let us not forget that the undergraduate of to-day becomes the alumnus of to-morrow, and as such he will look back on good teaching, kindness in his hours of trial, discipline justly administered when justly due, as helps in moulding his character and then his friendship and respect become the part of our reward. "I respect my calling and as long as I do others will respect it and me," should be the attitude of every teacher. College graduates frequently remark that they would not "waste their time teaching because there is no money in it." Such a man could not teach if he tried. His desire for wealth would render it impossible for him to give unselfish service.

Ask college administrators, students, teachers and alumni how to improve the status of teachers and the reply will almost invariably be "pay them larger salaries to attract more capable men." Greater remuneration would help (indeed is sadly needed), especially by raising the standard of living and by making it possible for the teacher to save a portion of his earnings. But the way to improve the status of the teaching corps is to give it some responsibility and power. In no other way can young men be developed into broadminded teachers worthy of the task of guiding your son and mine. *It is surprising that many college administrators do not realize that by keeping their teaching staff in the background they are taking the most effective method of dwarfing its initiative, destroying its ambition and rendering it impotent.*

TABLE II.

Normal Salaries Paid Heads of Departments at Some Middle States Colleges.

Institution.	Salary per Year at Present.	Institution.	Salary per Year at Present.	Institution.	Salary per Year at Present.
A	$1,300	G	$2,200	M	$3,000–$4,000
B	$1,400	H	$2,400 and house	N	$5,000
C	$1,900	I	$3,000+	O	$5,000
D	$1,900	J	$3,000	P	$5,000
E	$1,925	K	$3,500		
F	$2,000	L	$3,600		

To develop a man, give him power and responsibility. If this were done with teachers the result would be wonderful. The war has brought this out most forcibly. Because of increased duties or of a shortage of men many instructors and professors have been called upon to enlarge their activities either within the college or in industrial or government service. In numerous cases the results have been most gratifying. More than one college president has remarked to me during the past year that he did not realize how much ability professor ''so and so'' had until he called the professor in to perform some work, or how capable a certain instructor was until the government had given him an important duty to do.

It is not so much that higher salaries are needed, though they would help, but that more attention should be given to coöperation between administrative officers and the teaching corps.

It is the very common opinion among the best college professors that college administrators could accomplish much greater good by working through the medium of their faculties and instruction corps than by working single-handed. The study of organization and management methods receives altogether too little attention. I have been connected with two important institutions for twenty-four years and I have never seen an organization chart in either of them. And yet a college is a very complicated organism as was clearly shown recently when the War Department became a factor in college administration through the Students Army Training Corps system.

Table II shows the maximum salaries paid to professors by colleges in the Middle States. For obvious reasons the names of the colleges are withheld, the institutions being designated by letters. Notice the number that pay heads of departments below $2,000 per year. Such schools have no reason for existence. The professor of middle age who accepts a salary of that kind cannot perform properly his function because he is constantly confronted with the vision of poverty in old age. And yet we ask him to teach our sons chemistry, mathematics, character, French or fair dealing.

The accompanying chart shows the total incomes, salaries received from teaching, expenditures and savings of two professors in eastern universities. One has been teaching three or four years, the other about twenty years. The older man in question has always been more or less active in engineering practice outside of his institution and the effect on his total incomes due to this is clearly indicated. Relatively few teachers are so situated and constituted as to be able to materially increase their salaries by added effort outside of their colleges.

Many colleges are making the mistake of not getting their teaching corps together socially. Much is done in this line for students, and properly so; but almost nothing is done to bring about coöperation among teachers and departments. In some colleges the teaching corps is frequently assembled for the sole purpose of discussing educational problems. Much profit results from a carefully prepared discussion on such topics as recently treated in the Report of the Carnegie Foundation setting forth rules for admission of institutions and for the granting of retiring allowances to teachers. This is a new contributory system of providing old age annuities for college teachers and a few meetings spent in discussing the features of the plan and the desirability of the teachers availing themselves of its advantages would be profitable. Again, a short series of discussions of Dr. C. R. Mann's report on engineering education would quicken the interest of every teacher in the school if a program of the discussion be arranged in advance in order that each participant would be prepared to contribute something of merit. Moreover, it would be very helpful to send singly a limited number of instructors each year to educational institutions somewhat removed from the one wherein they teach normally to inspect methods of teaching, organization and equipment. Let each man remain a sufficient time to become well acquainted with the institution and to write a report on what he sees and learns, which upon his return should be read before his colleagues. To be of most value considerable emphasis must be placed on the quality of the report and upon its presentation. Similarly instructors would derive much benefit from being sent to conventions of national societies, alumni meetings, and for teachers of engineering, to great engineering works, provided the reading of a good report be insisted on. This cooperation would soon develop greatly the strong young men in the teaching corps, and improve the weak ones.

Depletion of Colleges Due to the War.

The colleges have been greatly depleted, especially in the three upper classes. They have likewise been badly disorganized and in the reconstruction about to take place some important improvements can be instituted. Many visits to colleges during the year 1918 has enabled me to see the changes wrought by the war. At one institution a single student constituted the class in physical laboratory and the professor of physics was laboring with him as diligently as if the laboratory was filled. At another, a professor of civil engineering was teaching bridge design to three students, and the head of the mechanical engineering department spoke of his senior class as ''my senior,'' for he had but one man in the senior class. A college which, last year, had eighteen men in the senior class of one of its engineering departments has five this year. Scores of cases like these can be cited to show the very great depletion in the upper years. In the autumn of 1918 the freshman classes were filled by the Students Army Training Corps.

The situation during the college year 1917–18 was about as follows: The army and navy were taking not only the entire output of the engineering schools, but were sucking the life-blood of these institutions by taking the undergraduates before they reached the ends of their courses. Both raw material and finished product were absorbed. But what was of equally grave importance was that the machinery of production was taken when the teachers enlisted in the army or navy, or left college to enter the industries. Raw material, finished product, machinery of production all were going. This draining process had been going on for two years and the demands of the War and Navy Departments were pressed regardless of the needs of the industries, and regardless of the life of the college. The predicament in which the college found itself was of no consequence as far as the college was concerned. It gave willingly and generously all it had to give. When, however, the technical colleges failed to supply technically trained men to the army, navy and essential industries it became necessary to give immediate relief to the college. This was attempted by the War Department by making it possible for students who met certain requirements to enlist in the Engineers' Reserve Corps. But as only those were eligible for this appointment whose academic standard was such as to place them in the "upper third," this provision was a failure as far as maintaining a normal supply of students under technical training was concerned. In the face of an unprecedented demand for technically trained men an acute shortage existed in the supply, and the reservoir, *i. e.*, the technical schools, from which they would normally be drawn, were nearly drained of upper classmen who had had sufficient training to make them serviceable.

Another system devised to give military training to students and to hold them in college to be ready when needed was the Reserve Officer Training Corps. This worked admirably during its brief trial of 1917 and 1918 and is an excellent plan for peace times. While it gave military training to students after they had entered the colleges, it was not instrumental in attracting men there, nor did it afford financial aid to students or colleges.

The Reserve Officers' Training Corps is the outgrowth of the students' summer military camps first proposed by General Leonard Wood in letters sent to college presidents in the spring of 1913 urging the establishment of the first camp at Gettysburg. This camp was succeeded by one at Burlington, Vt., in 1914, and those at Plattsburg every summer since. The Plattsburg idea has become an essential part of our military training for college men. Dr. Drinker and Dr. Hibben have from the beginning in 1913 been the leading spirits among college presidents in advocating the value of a six weeks' training at the summer camps and to them the country owes much for having perfected a system which when war came admitted of great and rapid expansion in producing officer material.

The Reserve Officers' Training Corps as outlined by the War Department in General Orders Number 49 provides a system for giving college students brief training in military science and tactics which if satisfactorily completed leads to appointment as reserve officers to be called upon in time of national emergency. Briefly outlined, it is as follows: The War Department provides officers, uniforms, arms and other equipment to those colleges which agree to maintain a two years' elective or compulsory course of military training and where at least 100 able-bodied students voluntarily join an R. O. T. C. unit, under an agreement which requires three hours per week to be devoted to military science and tactics during the freshman and sophomore years. Of the three hours, one is for a lecture, the other two are devoted to drill. Although elective, when once entered upon the military course becomes a prerequisite for graduation. Summer camps are not required of freshmen and sophomores. At the end of the sophomore year the student may discontinue, or he may, if recommended by the professor of military science and the president of the college, continue the work, taking five hours per week throughout the junior and senior years and also the summer training in camps. In case a student agrees to take the work of the junior and senior years, he may be furnished by the government with commutation of subsistence, which in the past has amounted to only thirty cents per day. While going to and from, and while residing at summer camps maintained for the practical instruction for a period of not exceeding six weeks in any year, members of the R. O. T. C. have subsistence furnished by the United States, and they also receive their traveling expenses if appropriation permits. The President of the United States is authorized to appoint as reserve officers in the army, not exceeding 50,000, graduates who satisfactorily complete the four years' course, to serve the United States as reserve officers during at least ten years after appointment. In peace times the President may appoint and commission any reserve officer as a temporary second lieutenant for purposes of instruction for not exceeding six months. In times of war he may order them to active duty.

While enlistment in the Engineers' Reserve Corps, previously mentioned, was beneficial in holding a few capable men in college till the end of the college year in the summer of 1918, this system would have been found totally inadequate had it alone been relied upon and had the war continued. Accordingly, in the summer of 1918 the War Department announced the Students' Army Training Corps, which was the only practical system for securing office material and providing training for the young men who were thus brought together. That some drastic action had to be taken if the supply of technically trained men was to be maintained was clear to anybody who had visited the colleges in the spring of 1918. The accompanying diagram shows the decrease in number of men graduating from Lehigh University in the last five years, and the same conditions existed at all colleges.

In June, 1918, Table III (herewith presented) was prepared to ascertain the number of men graduating from the civil, mechanical and electrical engineering courses of the principal colleges. These three courses have in the past furnished nearly the entire output of engineers. The total number of men graduating last June is shown by the table to be 1844, and as most of these went into the army and navy a totally insufficient remainder was available for the essential industries. Moreover, this table clearly shows that the colleges were operating very inefficiently because many of them were graduating less than half a dozen men in each of the three important engineering courses. Indeed the average of all schools tabulated was only eleven men per course per school. This great falling off from previous years took place in the face of an unprecedented demand for technically trained men.

In his work among the shipyards and colleges the writer had an excellent opportunity of seeing on one hand the demand for men and on the other the dwindling supply. A total of forty colleges were visited on the Atlantic and Pacific seaboards, 114 lectures given, 23,400 miles traveled and about 900 technically trained men placed in shipyards. Depletion of the upper classes had taken most of the available men by September, 1918, and as the demand from the shipyards were still very great, several colleges started intensive training courses in naval architecture and marine engineering. Of these, the Massachusetts Institute of Technology's course of ten weeks' duration for technical college graduates working all day, every day, was very successfully carried out.

Another interesting method of increasing the output of technically trained men was that adopted by Cornell, Massachusetts Institute of Technology, and Throop College of Technology. These institutions continued their regular work during the summer and autumn of 1918 for their junior classes, thus graduating, between September and December, 1918, men who otherwise would have finished in June, 1919. Just before the men graduated at Massachusetts Institute in

TABLE III.

Number of Men Graduating from Leading Engineering Courses in Spring of 1918.

Civil Engineering.		Mechanical Engineering.		Electrical Engineering.	
Institution.	No. of Graduates.	Institution.	No. of Graduates.	Institution.	No. of Graduates.
Cornell Univ.	42	Stevens Inst.	66	Mass. Inst. Tech.	43
Univ. of Michigan	42	Mass. Inst. Tech.	53	Penna. State Col.	34
Mass. Inst. Tech.	40	Univ. of Mich.	36	Univ. of Michigan	34
Cooper Union	39†	Georgia Tech.	30	Cornell University	30‡
Rensselaer P. Inst.	27	Cornell Univ.	30‡	Univ. of Illinois	29
Iowa State College	26	Univ. of Illinois	26	Univ. of Wisconsin.	26
New York Univ.	21	Univ. of Wis.	26	Iowa State College	23
Penna. State Col.	20	Sheffield School	23	Renesselaer P. Inst.	22
Univ. of Illinois	20	Case School	20	Worcester P. Inst.	20
Lehigh University	19	Penna. State Col.	19	Cooper Union	19†
Brooklyn P. Inst.	18	Clemson College	17‡	Univ. of Colorado	19
Univ. of Penna.	18	Worcester P. Inst.	15	Clemson College.	17‡
Univ. of Wisconsin	17	Brooklyn P. Inst.	14	Union College	17
Univ. of California	17	Lehigh University.	14	Georgia Tech.	17
Case School	15	Syracuse Univ.	13	Univ. of Missouri	13
Cooper Union	15*	Univ of Penna.	13	Ohio State Univ.	12
Ohio State Univ.	14	Oregon State Col.	12	Syracuse Univ.	12
Tufts College	13	Univ. of Minn.	12	Univ. of Kansas	12
Worcester P. Inst.	12	Iowa State Col.	11	Virginia P. Inst.	12
Clemson College.	11	Rensselaer P. Inst.	11	Carnegie Tech.	11
Lafayette College.	11	Ohio State Univ.	10	Miss. A. & M. Col.	11
Syracuse Univ.	11	Carnegie Tech.	9	Univ. of Maine.	11
Univ. of Missouri	11	Univ. of Colorado.	9	Univ. of Minnesota.	11
Leland Stanford Jr.	10	Brown University	8	Case School.	10
Univ. of Colorado	9	Kansas State Univ.	7	Kansas State Univ.	10
Univ. of Wash.	9	Leland Stanford Jr.	7‡	Sheffield School	10
Washington Univ.	9			Oregon State College	8
Carnegie Tech.	8	Johns Hopkins Univ.	6	Univ. of Penna.	8
Sheffield School	8	Lafayette College	6	Johns Hopkins Univ.	7
Union College	8	New York Univ.	6	Leland Stanford Jr.	7‡
Univ. of Minn.	8	Univ. of California	6‡	Texas A. & M. Col.	7
Georgia Tech.	7	Univ. of Maine	6	Throop College.	7
Throop College.	7	Cooper Union.	5†	Lafayette College.	6
Univ. of Vermont	7	Tufts College.	5	Lehigh University	6
Kansas State College	6	Miss. A. & M. Col.	4	Univ. of Texas	6
Texas A. & M. Col.	6	Tulane University.	4‡	Wash. State College	6
Univ. of Utah	6	Virginia P. Inst.	4	Brooklyn P. Inst.	5
West Virginia Univ.	6	W. Va. University.	4	Univ. of California.	5
Johns Hopkins Univ.	5	Univ. of Kansas	3	Univ. of Oklahoma.	5
Tulane University.	5	Univ. of Missouri.	3	Cooper Union	4*
Univ. of Maine.	5	Univ. of Oklahoma	3	Tulane University.	4‡
Univ. of Texas.	5	Washington Univ.	3	Univ. of Vermont.	4
Univ. of Kansas	4	Texas A. & M. Col.	2	Univ. of Washington	4
Univ. of So. Carolina	4	Univ. of Arkansas.	2	West Virginia Univ.	4
Columbia Univ.	3	Univ. of Vermont.	2	Brown University	3

Civil Engineering.		Mechanical Engineering.		Electrical Engineering.	
Institution.	No. of Graduates.	Institution.	No. of Graduates.	Institution.	No. of Graduates.
Miss. A. & M. Col...	3	Wash. State Col...	1	Univ. of Arkansas..	3
Univ. of Arkansas..	3	Throop College ...	1	Univ. of So. Calif...	3
Univ. of So. Calif...	3	Univ. of Utah	1	Washington Univ...	3
Vanderbilt Univ. ...	3	Univ. of Wash. ...	1	Univ. of Utah	2
Brown University ..	2	Vanderbilt Univ...	1	Tufts College......	1
Oregon State Col. ..	2	Columbia Univ....	0	Univ. of Florida ...	1
Univ. of N. Carolina	2	Cooper Union.....	0*	Univ. of N. Carolina	1
Univ. of Oklahoma.	2	Univ. of Alabama.	0	Northwestern Univ.	1
Virginia P. Inst.....	2	Univ. of Florida ..	0	Columbia Univ.....	0
Northwestern Univ.	1	Univ. of N. Carolina	0	Univ. of Alabama..	0
Wash. & Lee Univ..	1	Union College	—	Vanderbilt Univ....	0
Univ. of Florida ...	0	Univ. of S. Calif...	—	New York Univ....	—
Univ. of Alabama..	0	Univ. of Texas ...	—	Stevens Institute...	—
Wash. State Col....	0	Wash. & Lee Univ.	—	Univ. of S. Carolina	0
Stevens Inst.	—	Univ. of S. Carolina	—	Wash. & Lee Univ..	—
Total	648		590		606
Average.........	11		11		11

* Day school students.

† Night school students.

‡ Combined mechanical and electrical engineering courses.

September a representative of the Emergency Fleet Corporation gave a lecture on shipbuilding and an engineer from the Newport News Shipbuilding and Dry Dock Company engaged twenty-eight members of the class, who reported to the shipyard immediately upon graduation. Each of the above colleges have the unique distinction of having graduated two classes in the same year. An interesting detail of this intensive system was seen at Throop College, where students and faculty gathered upon the campus every morning at ten o'clock for fifteen minutes' physical training, this being possible through the winter under southern California's clear sun.

The Course of Study.

War has resulted in a searching analysis of college courses of study. Except in vocational training the very important question of "how to teach" has not received as much attention as "what to teach." While both are of great importance, it is to the college curricula that attention is now directed, because their revision is under consideration by most faculties.

Choice of Vocation.—Most students have not, upon entering arts courses, chosen their vocation and perhaps it is well that it is so for the boy then has an opportunity to learn for the sake of learning. And yet I believe that the classical college would do better if it gave in the freshman or sophomore year a course of lectures planned to instruct the boys about the professions as well as the different fields of industrial and commercial activity. With the professional schools of medicine, law and engineering it is somewhat different. When boys go to an engineering school they do so with the purpose of becoming engineers, and while they generally have a fairly clear idea as to the particular engineering course they desire, a few students change from one course to another during their freshman year. Such changes are readily made without loss of time because the various engineering curricula are practically identical in the first year. Most boys, however, who enter engineering courses remain therein and continue engineering work after graduation. They have the builder's instinct and nothing can and nothing should deviate them from their purpose.

Professional and Cultural Subjects.—Students of engineering have in general too many subjects at one time. They have too many technical courses and unfortunately have very little interest in those of non-technical nature. A so-called cultural subject must be taught in an excellent way to hold a class of young engineers. In saying that there are too many technical subjects I do not wish to belittle them, for I consider them of prime importance. They must continue to demand the student's respect, his interest, and his best work. But he must know something besides his applied science. Assuming a corps of instructors of equally good ability it seems that an undergraduate engineering course should be one third cultural and general science studies, one third economics and one third applied science. And where in the curriculum is the best place for these various subjects? Let us put ourselves in the boy's place. He has looked forward for several years to his entrance into his engineering college course. At last he reaches the campus, and his heart is filled with admiration and joy. His hopes are about to be realized. He finds the campus and buildings a most beautiful and inspiring sight and his enthusiasm runs high. It is with these feelings that he approches "old hall" for his first recitation. He expects something new, something better, than he had at high school. But he finds he has almost exactly the same subjects to study—mathematics, English, French or German, chemistry or physics. His enthusiasm drops x per cent. at the first recitation and another x per cent. at those immediately following as he rushes from building to building in the hope of finding something to satisfy his longing to become an engineer. If he stands the test he passes over this bridge of sighs and into work of subsequent college years. But he frequently is unable to overcome the transition period from high school to college and fails; leaving college at either the end of the first or second terms of the freshman year. It is stated that only 40 per cent. of engineering students graduate in the allotted time. I know of no careful analysis having been made as to the causes of failure at institutions with which I have been a part, but I believe the loss of enthusiasm in the freshman year is an important contributory influence. It is not to belittle the studies—mathematics, French, English, etc.—mentioned above that these remarks are made, for those studies are of great importance, in fact essential. But is it proper to give all the technical work above the freshman year? I think not. A boy coming to college with the feeling described above should have some entirely new work; and it should be of the highest grade, even though purely inspirational. Our courses supply either inspiration, information or mental training. Obviously, care must be taken to give no work in the freshman year which will be repeated in later years.

The proper place in the curriculum for cultural work is a difficult thing to decide. It is, however, clear that some of these subjects can properly come in the upper rather than the lower years and if a boy is given some technical work in his freshman year and cultural subjects later may he not approach the latter with greater interest and better results.

Engineering is largely concerned with making a dollar do the greatest amount of effective work. Economics is, therefore, an essential tool for the engineer and he should have in college the fundamentals, including work in accounting, business law, banking and industrial management. The writer confesses that he was past thirty years of age before he knew that he could discount at a bank a note he had received in payment for professional services rendered. He was ignorant of the fact that he could, by discounting the note, receive his money immediately and not wait for it till the date of maturity. No engineering student should be ignorant of such a simple, fundamental banking operation.

College faculties are now trying to answer these questions: How many exercises per week should a student have? How many hours of class room work and hours of home work? How many subjects should the student carry at once? As college teachers and students are constituted eighteen exercises per week can be placed in the schedule with an allowance of two hours, for preparation for each, or fifty-four hours of combined class work and outside preparation per week. It would be very much better if most professors maintained a higher standard. In this case twelve exercises per week would be ample with three hours of serious work required outside for each exercise. This would permit about four subjects at a time and to include all the subjects now thought desirable in engineering courses more than four years would be required, because even by operating three terms per year only 48 eight courses of study could be included. This is less than most schools now give as shown by Table IV. But too many courses are now required. Imagine the mental gymnastics demanded of a boy who in one morning is ex-

TABLE IV.

Number of Subjects in Civil Engineering Curricula at Some Typical Institutions.

	Freshman.		Sophomore.		Junior.		Senior.	
	1st Term.	2d Term.	1st Term.	2d Term.	1st Term.	2d Term.	1st Term.	2d Term.
Massachusetts Inst. of Tech. . . .	6	7	7	9	9	9	8	8
Princeton University	6	6	6	6	6	6	6	6
Carnegie Institute.	5	7	5	6	6	7	7	9
Cornell University	5	4	6	5	5	6	6	6
Pennsylvania State College.	6	6	6	6	6	7	8	9
Lehigh University.	6	5	6	6	6	6	6	6

pected to do serious work in French, physics, mathematics, chemistry—a common requirement.

It would be well worth while to try a three-year course with three terms per year with five subjects per term. Tufts College announces a program of three subjects in each of three terms yearly.

Sudents' Army Training Corps.

The primary purpose of the Students' Army Training Corps (S. A. T. C.) was to utilize the executive and teaching personnel and the physical equipment of about 600 educational institutions to assist in training our army and navy, especially for training officer-candidates and technical experts of all kinds needed in the service. The corps was divided into two sections, the "collegiate" and the "vocational." Before the S. A. T. C. was authorized by Congress in the summer of 1918 the War Department had been conducting training centers for instructing soldiers as trade specialists in the army. This vocational training reached enormous proportions and varied in character from excellent to mediocre. Automobile mechanics, carpenters, railroad track men, road builders, instrument repair men, were among the many types of workers taught in these training centers, which were in most cases located at colleges. It was a relatively simple matter to expand this vocational training system into the larger one which also encompassed the regular college students in about 600 institutions at which S. A. T. C. units were established.

Advantages of S. A. T. C.—The S. A. T. C. had some very good qualities, notwithstanding the fact that we, the professors, were very restive under the system. In the first place, it created a large reservoir of young men in the collegiate section which, had the war progressed for a year or more, would have been a source of great help in producing officer-material. Here we had the picked youth of the country, under training, ready to go when called, even straining at their leashes to go before; and ready to make the last great sacrifice if need be. This material was being trained physically and mentally. Practically every college president with whom I have talked stated that the students were greatly improved physically. At Pennsylvania College, Gettysburg, Pa., students gained an average of 11½ pounds in weight during their S. A. T. C. training.

The system enabled many boys, who otherwise could not have done so, to start on a college course. Their clothing and subsistence were furnished by the government and in addition they were paid by the War or Navy Departments. The mental and physical training outlined by the War Department would have meant much to thousands of our country's young men.

Many a college owes its present existence to the S. A. T. C. because the demand for men and the desire of the young men themselves to enlist in the service would have left many colleges without students at their opening dates in the autumn of 1918. Financially it saved many a struggling institution. As a result of the inducements held out by the S. A. T. C. thousands of students went to college because they saw a short cut to an officers' training camp and as the colleges received $1.00 per day per student for food and shelter and from fifty cents to $1.00 per day additional for instruction, these institutions were properly reimbursed for the use of their men and equipment.

The infusion of new blood into the colleges made many new problems, the solution of which quickened the teaching corps and administrative officers, made them help in winning the war and instituted a searching analysis as to their aims and methods. Many teachers whose classes were small and who felt they were not utilizing their ability to the best advantage by remaining in college either enlisted in the Army or Navy or entered other governmental service of the industries.

Disadvantages of S. A. T. C.—It is unfortunate that the S. A. T. C. system did not have a fair trial. In general, the only place wherein the system failed was in educational work and in some schools even this was fairly well maintained. In the first place Congress passed the enabling legislation so late in the summer of 1918 that the War Department did not have time to work out the problems before colleges opened. Then came the influenza epidemic and colleges were turned into hospitals. Some institutions did not attempt to begin educational work before November 15, *i. e.*, two months or more after they should have started. The students were kept at these colleges, drilling but attending no classes. Of course, the fundamental errors in inaugurating the S. A. T. C. were soon apparent. The divided power and responsibility between military officers and college authorities could never be made to work. Young officers, many of whom had never had any real authority or responsibility before, thought the government had "taken over" the colleges and thereupon assumed full control, thus going far beyond their orders and far beyond the desires of the committee in charge in Washington. The scarcity of officers of sufficient education and breadth of view to coöperate with colleges constituted a serious handicap. One extreme case was that of a lieutenant actively in charge at one of the best schools in the country, who was, in the spring of 1918, a student in a second-rate college preparing to enter said school in the autumn of 1918. While serving in command at the school he had charge of several hundred men every one of whom was a college graduate. Another was that of a young lieutenant who remarked to a visiting government official about the college president, "He don't cut no ice here."

Then, again, these young officers lost sight of the fact that officers, not privates, were being trained, and while military discipline was an essential part of the student's training he also must have academic training. Imagine if you please a coast artillery officer without training in mathematics. Yet much time was wasted by unnecessary military duties which interfered with, or totally excluded, academic work.

The effect on student attendance on classes is shown by the accompanying diagram giving percentages of absences from the most important engineering subject of an eastern technical school. Before the war began in 1914 the absences were fairly small, not exceeding 4 per cent. The unrest caused by the war increased the absences from 1914, till, in the autumn of 1918, the combined influence of influenza and S. A. T. C. nearly wrecked the course with absences of 7 to 32 per cent. This interference was a very serious source of friction between most faculties and military officers and unfortunately the officers seldom appreciated the extent of the evil or even that an evil existed.

Most of us college men were apt to view the S. A. T. C. only through our short focus lenses. We saw the interference with our classes, we felt the loss of authority we had so long held and we were so far away from the real scene of activity, namely, Chateau Thierry that we could not see the necessity of a reservoir for officer material. The enemy was almost at the gates of Paris, and had he then broken through the battle front the result probably would have been disastrous. At this critical moment the need for officers was very great; the only way to get them was to train them; and the colleges were called upon to coöperate with the War and Navy Departments to do it. The colleges responded as they are ever ready to respond. And if the occasion ever again presents itself the colleges will say, "We are ready to serve."

THE JOHNS HOPKINS UNIVERSITY.

BY J. B. WHITEHEAD,

Professor of Electrical Engineering.

HISTORICAL.

The Johns Hopkins University was founded by Johns Hopkins, a merchant of Baltimore, who bequeathed the greater part of his estate for the establishment of a university and a hospital. The founder died in 1873. The first President of the University, Daniel C. Gilman, was inaugurated in 1876 and instruction began on October 3 of that year.

The work of the University began in two houses at the corner of Howard and Little Ross Streets, in the heart of Baltimore. As the need arose, other buildings were constructed, including the chemical laboratory, biological laboratory, physical laboratory, gymnasium, a home for the Young Men's Christian Association, and finally McCoy Hall, a large central building containing offices of administration, assembly room, the general library, and numerous smaller rooms for seminaries, departmental libraries, class rooms, etc. This entire group of buildings, excepting the chemical laboratory, was vacated in the summer of 1916.

The Johns Hopkins Hospital was dedicated May 7, 1889, and this paved the way for the opening of the Medical School of the University four years later in 1893. The Hospital occupies a commanding site in the eastern part of Baltimore at a considerable distance from the first home of the University, and also from the new home of the University, to be described below. The buildings of the Medical School are adjacent to those of the Johns Hopkins Hospital, with which it is closely associated, in accordance with the expressed wish of the founder. The group of buildings includes a central structure chiefly devoted to administration, large private wards, a considerable number of separate buildings containing the public wards, a large dispensary building, a surgical building and amphitheater, a pathological institute, a nurses' home and the four buildings comprising the laboratories, library, seminaries and class rooms of the Medical School. The Harriet Lane Home for Invalid Children, the Phipps Psychiatric Clinic, the Phipps Dispensary for the Treatment of Tuberculosis, and the Brady Urological Clinic are important adjuncts to the Hospital and are situated within its grounds.

Only students who have taken a baccalaureate degree are admitted to the Medical School. Professional training in this school, therefore, is on a strictly graduate basis. It constitutes one of the most important fields of activity of the University, but no further description can be attempted within the purposes of this article.

In 1902 it was announced that a suburban site, embracing 176 acres of land within the city limits and about two miles directly north of the Washington Monument had been given to the University by a small group of its friends. A gradual development of the new site was begun at once and continued, as necessary funds were received, until 1916, at which time a practically complete move of all the work of the University, except that of the Medical School, was made to new buildings at ''Homewood.''

The principal building of the present Homewood group is Gilman Hall, which contains the general library and all of the non-laboratory departments, as well as the offices of administration. Other buildings are those of the Department of Engineering, described below, the Laboratories for Botany and Plant Physiology, the Students' Activities Building and the original Carroll Mansion, built by Charles Carroll, the signer, in 1809, to be a residence for his son, and which is now known as the Johns Hopkins Club. Plans for the physical and chemical laboratories are completed and construction will soon be begun on at least one of these. Plans are also under way for the erection of the first of a dormitory group within

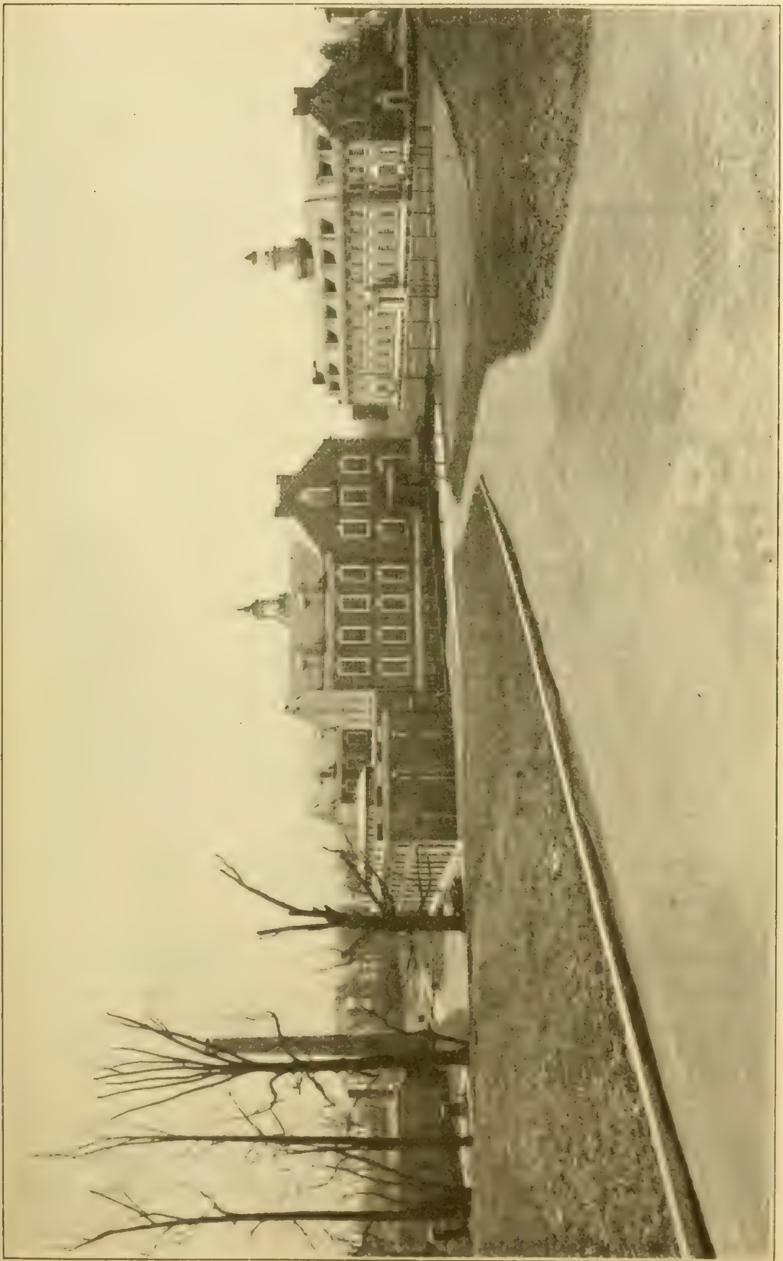

Fig. 1. Power Station, Mechanical and Electrical Laboratory, Civil Engineering Laboratory.

the near future. At present temporary quarters are provided in Gilman Hall and in the engineering buildings for the laboratories of physics, chemistry, geology and biology.

In 1916 the Rockefeller Foundation of New York offered to coöperate with the University in the establishment of a School of Hygiene and Public Health, which offer was accepted by the University, and courses of instruction were opened in 1918. The temporary home of the School of Hygiene is the former physical laboratory of the University, in the heart of the city.

COURSES OF INSTRUCTION.

The University has had in view, from the beginning, two main objects—the advancement of learning through investigations conducted by its teachers and its properly qualified students, and the communication of learning through carefully planned courses of instruction. The facilities which it provides and its methods of administration are intended both for the encouragement of research, in the case of those competent to undertake it, and for the discipline and guidance of those whose chief concern is the acquisition of knowledge. The work of the University is carried forward under the four faculties: of Philosophy, of Medicine, of Hygiene and Public Health, and of Engineering. The Faculty of Philosophy conducts the principal graduate activity of the University leading to the degree Doctor of Philosophy. It also directs the work of the College of Arts and Sciences leading to the degrees Bachelor of Arts and Bachelor of Science. The character of instruction under the Faculty of Medicine has already been described. Both graduate and undergraduate instruction are conducted by the Faculty of Hygiene and Public Health leading to the degrees Doctor of Public Health, Doctor of Science in Hygiene, and Bachelor of Science in Hygiene.

The students who may be enrolled under the Faculty of Engineering are: (1) those who have obtained degrees in engineering from schools or colleges in good standing and who desire to follow advanced courses or pursue investigations in engineering subjects, and (2) undergraduate students who are looking forward to the degree Bachelor of Engineering. This degree is conferred on completion of four years' courses in either Civil, Electrical or Mechanical Engineering. Noteworthy features in the character of the undergraduate instruction are two years in common for all students, sound training in mathematics and in underlying sciences, one full course in a general educational subject in each year, an interrelation among the professional studies of the third year, and a working relation with the industries of Baltimore for the placing of students in industrial work during the second and third summers. The Department of Engineering also supervises a course in Chemistry, in which special emphasis is laid on the industrial applications of that science. This course leads to the degree Bachelor of Science in Chemistry.

Graduate courses are scheduled in each of the three branches of Engineering mentioned above. So far the number of graduate students has been small. It is the policy of the University, however, to encourage original investigation, not only through graduate students, but through the work of its faculty. Noteworthy contributions as a result of these activities have been made in the following directions: a method for purification of lubricating oils; the rapid cooling of water of condensation; the recovery of the by-products of the manufacture of illuminating gas; the design of power station chimneys; the electric properties of air; the measurement of high alternating voltage; the measurement of iron losses at high frequencies; the errors of polyphase wattmeter connections; the predetermination of the regulation of continuous current machines; the magnetic analysis of steel for rifles; an electromagnetic method of submarine detection; tuning fork control of the speed of large continuous current motors.

THE ENGINEERING LABORATORIES.

The Department of Engineering was established under the provisions of an Act of the General Assembly of the State of Maryland in its session of 1912. The Act provided a liberal

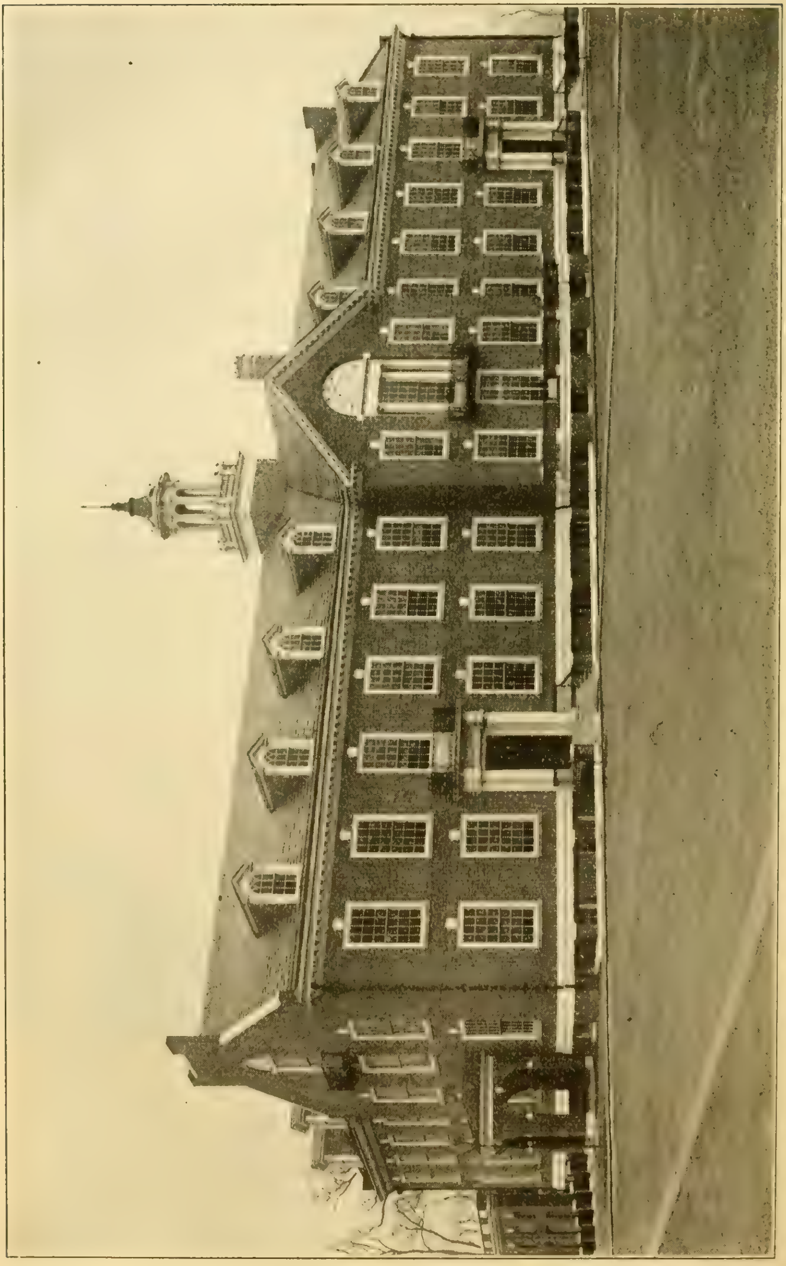

FIG. 2. Mechanical and Electrical Engineering Laboratory.

appropriation for the erection of the buildings and the purchase of equipment and a continuing annual appropriation available to the University each year. Instruction was begun in the fall of 1913 in the original buildings of the University located in the heart of Baltimore. In October, 1914, the work of the Department of Engineering was removed to the first of its laboratories at the new home of the University located at Homewood, in the northern part of the city. Since that time the first group of engineering laboratories has been completed.

In Fig. 1 is shown a general view of the engineering laboratories located on the south quadrangle of the Homewood campus. In the center is the Laboratory of Mechanical and Electrical Engineering; to the right that of Civil Engineering; and to the left the Power Station, in which is installed a considerable portion of the laboratory equipment in Mechanical and Electrical Engineering. In these buildings instruction is conducted in the subjects Civil, Electrical and Mechanical Engineering, and in Industrial Chemistry.

Mechanical and Electrical Building.

This building was designed to meet the requirements of both graduate and undergraduate instruction, with liberal provision for experimental investigation. It provides ample lecture and drafting rooms, research rooms and laboratories, in addition to offices, auditorium, and such other service rooms as are required for the convenience of students and faculty.

The building faces west on the south quadrangle of the Homewood development and has a frontage of 204 ft. At either end a wing extends eastward and the two wings are joined at the back by Machinery Hall. The depth of the building is approximately 160 ft. and the ground plan, including areas, covers an area approximately 226 ft. by 173 ft. The main portion of the building has three floors and an attic.

The basement contains the mechanics' shops, storerooms, storage battery room, space for ventilating fans, locker and toilet rooms, in addition to a number of undergraduate laboratories and separate rooms for special experimental and research work. The basement connects with the main floor of Machinery Hall through the two wings and also through a central passage. The two wings and the central passageway in the basement enclose two large interior courts of ample size for giving light into all interior rooms and also for out-of-door space for experiment.

The first floor includes an auditorium, or main lecture room, seating 150 people, in which is installed every facility for experimental demonstration in lecture and class work. In addition this floor includes large laboratories for electrical measurements and instrument testing, drawing and study rooms for advanced students, a room for students' engineering societies, three class rooms and several smaller rooms for special purposes. Access may be had also from this floor to a gallery running the full length of Machinery Hall.

The second floor contains the library and reading room, large drawing rooms, several class rooms, professors' offices, laboratories for electric illumination and other purposes. There is an attic of good elevation. It provides storage space, a room for blueprinting and liberal provision for increasing demands for laboratory space.

Machinery Hall is the principal laboratory for experiments with rotating and heavy machinery in the fields of electrical and mechanical engineering. This large space is of steel construction of factory type. It is well lighted and ventilated by means of monitor skylights and large windows on all sides. It is approximately 200 ft. long by 50 ft. wide and 24 ft. high under the room trusses and has a basement under the south end. It contains a travelling crane and the necessary switchboard for controlling the extensive system of light, power and experimental electric circuits in the building. The north end of the hall is devoted to the testing of alternating current and direct current machinery, and the south end to the testing of certain portions of the equipment in mechanical engineering, described in further detail below. The concrete floor of Machinery Hall is fitted with bed plates for the tem-

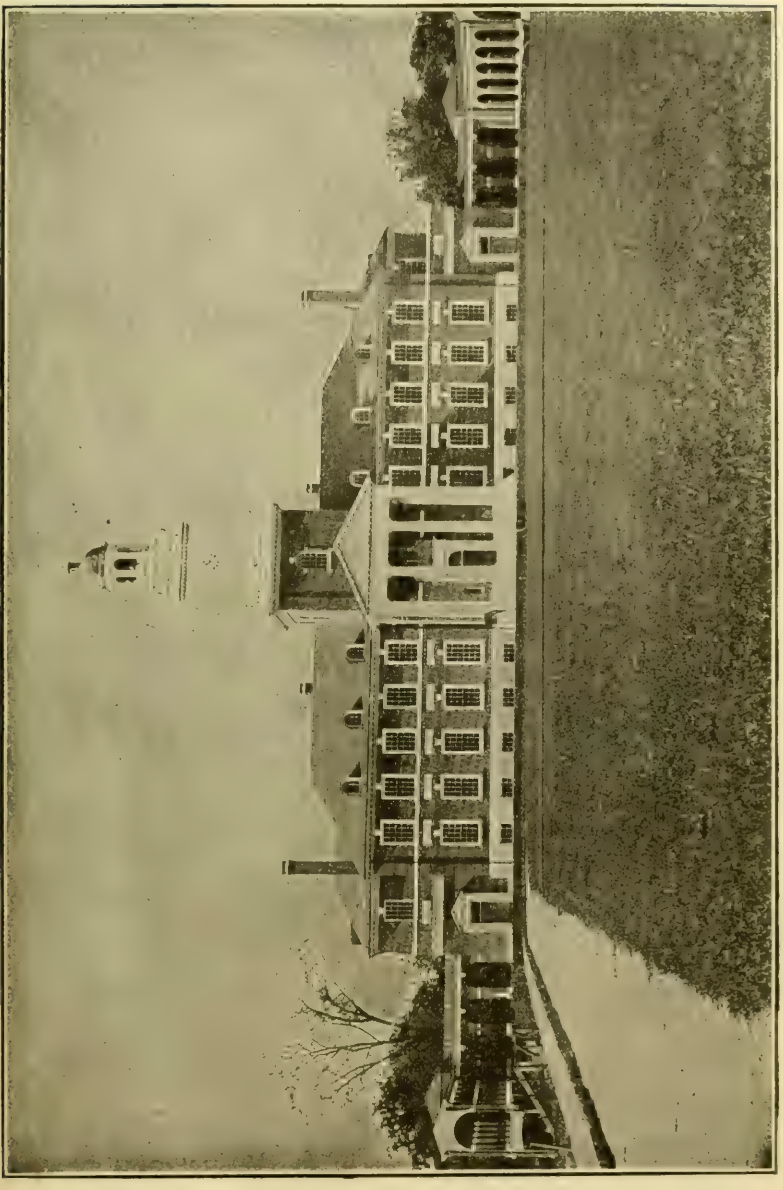

FIG. 3. The Academic Building—Front Elevation.

porary installation of machinery of various types and suitable for easy alteration of the location of the laboratory machines. There is also a gallery extending the full length of Machinery Hall, which is used for certain classes of experimental work requiring long distances.

An interesting feature of the electric equipment of the building is the system of tunnels and wire shafts whereby ready access is available throughout their lengths to the extensive open system of power, lighting and experimental cirsuits. The system of distributing boards and the method of local distribution for experiment are also interesting.

The laboratory equipment for electrical engineering is entirely modern and covers a wide field. Additions to this equipment are still in progress. The machine laboratories embrace all standard types of generators and motors. All generators are motor driven with speed control. Fixed instrument tables, rheostat and switch mountings and supports, connection posts and cable terminals are all standardized. While the student assembles all his equipment and identifies all circuits and connections, the aim has been to reduce the time required in these processes to a minimum.

In addition to the machines for the routine of instruction, a number for general and special purposes are provided; among them may be mentioned a 50 K.V.A., single phase, sine wave alternator; 2 30 K.V.A. D. C. motor-driven, 3-phase, 6-terminal machines; a 10 K.W. rotary converter; 2 7½ K.W. rigidly coupled single-phase, smooth wave alternators with ratio of frequencies 1:3, and a wide range of speed operation; alternators of 133, 600, 3,000 and 5,000 cycles; a variety of transformers, including one of 10 K.V.A. capacity at 110,000 volts, and a unit furnishing 15,000 volts continuous difference of potential.

Throughout the building a number of rooms have been equipped for the usual program of experiments in measurements, storage battery and transformer operation, arc and incandescent illumination, telegraphy, telephony and radio transmission.

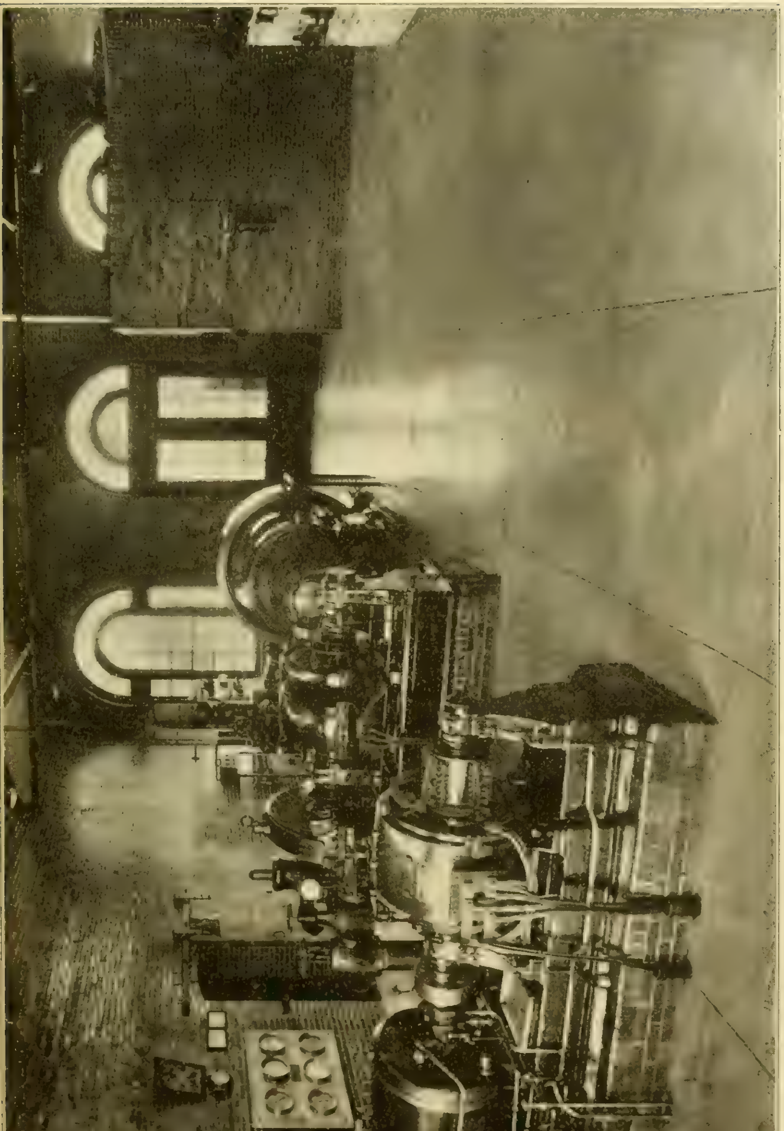

FIG. 4. Interior of Power Station.

Particular thought has been given to the facilities for special experiment and research. All types of instrument of precision are provided, numerous special machines and ample space in separate rooms. Advantage has been taken of the high point afforded by the chimney of the power station to install an antenna for radio telegraphy over 300 ft. long, the opposite end being attached to the north wing of the laboratory buildings. Opportunity and equipment is offered here also for special investigation.

The south end of Machnery Hall contains a part of the equipment for mechanical engineering, although, as indicated below, a greater portion is to be found in the power station. Among the equipment in Machinery Hall is a 6 in. by 7½ in. vertical slide-valve engine and an 8½ in by 24 in. Corliss engine, both especially arranged for valve setting and both equipped with brakes for economy and load tests.

A 15-ton Frick refrigerating machine with full equipment is also installed. The set consists of a horizontal steam engine with Corliss valve gear driving two vertical ammonia cylinders. All cylinders are furnished with reducing motions so that indicator cards may be taken. The ammonia gas, after compression, passes to a double pipe condenser on the gallery above, where the heat taken up by the cooling water can be measured. An accurate method of weighing liquid ammonia has been installed. A triple pipe brine cooler is located in the basement. The brine circulates through the cooler and is discharged over a V-notch weir into either of two weighing tanks from which it flows into a receiver tank in the basement. The system is arranged for operation either on the dry or flooded system.

There is also an air compressor of Ingersoll-Rand type, with a capacity of 400 cu. ft. per minute at 100 pounds pressure. It is compound on both steam and air ends and in this way an excellent opportunity is afforded for the study of heat interchanges. The compressed air passes into a receiver and is then discharged through an orifice.

There are two exhaust systems in the basement to which

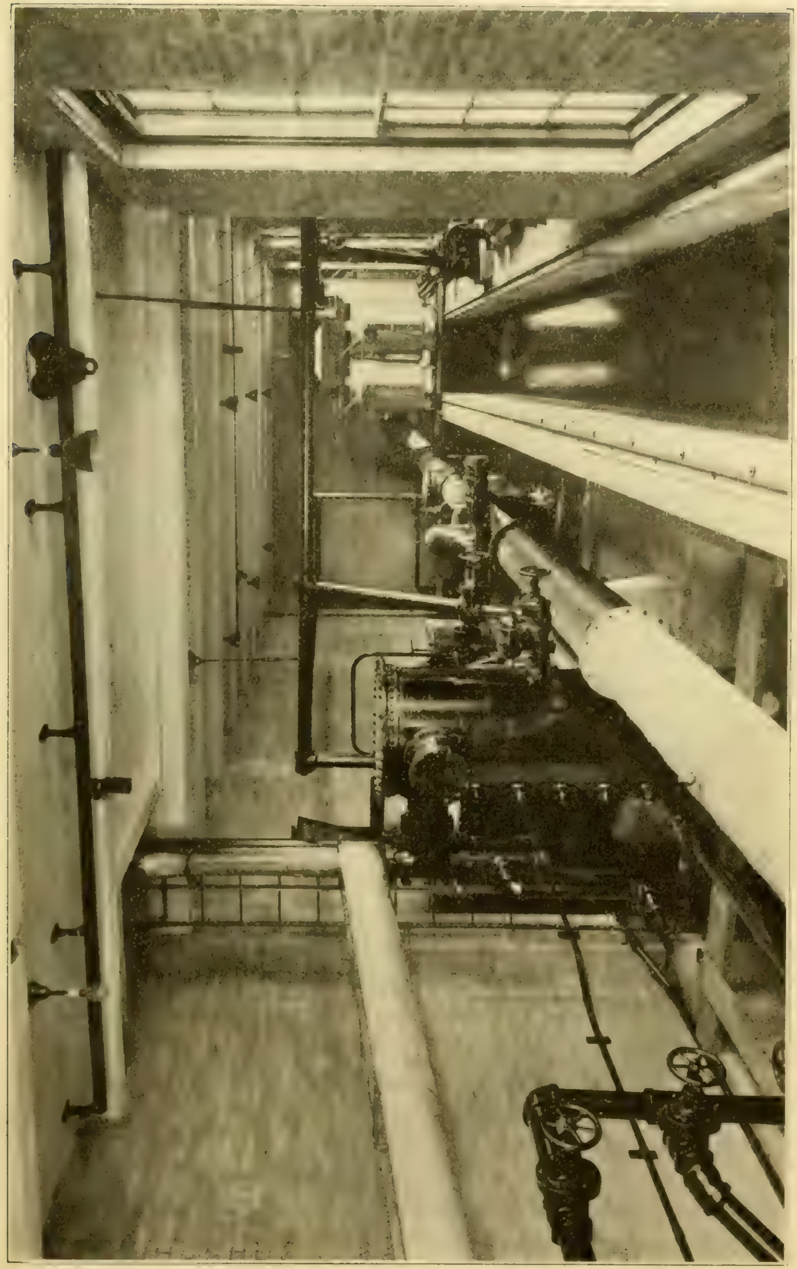

FIG. 5. Part of the Laboratory of Hydraulics.

any engine may be connected. One of these is the University heating system and the other a Wheeler surface condenser, fitted with a motor-driven Pratt Rotrex pump for high vacuum.

This portion of Machinery Hall also contains a pipe shop and a number of less striking types of machinery. Other portion of the equipment of mechanical engineering will be described in connection with the power station.

Civil Engineering Building.

The Civil Engineering Building is west of and faces the Mechanical and Electrical Building, to which it is similar in general architectural treatment. The two buildings have the same length, but the Civil Engineering Building is the smaller, in that it lacks the wings at either end, and also Machinery Hall.

In the basement three large laboratories are provided. Each laboratory suite consists of a large room for the accommodation of the heavier machines, tanks, channels for the flow of water and similar devices, and a smaller room planned especially for research. In the central portion of the building, in the wing which extends 47 ft. to the westward is the main Structures Laboratory and a research room devoted to investigation and laboratory instruction in the structural division. Here are located principally machines for testing the various materials of construction and also equipment for testing cement and sands. Opportunity and space are provided for special work on simple structural elements in full-size pieces, such as beams of various kinds, arches of reinforced concrete, brick or stone, and frame structures in wood or steel.

In the southern portion of the basement is the hydraulic laboratory consisting of a long room with specially designed channels, measuring bays and steam pipes for experiments on the flow of water, and a research room devoted to studies in sanitary engineering. In the north end of the basement are two similar rooms devoted to transportation problems which are concerned principally with highway and canal construction, the physical elements of steam and electric railway lines, and, in general, the structural features of all that has to do with systems of transportation.

A particular type of construction has been chosen for the ceiling of the basement corridor, with a view of having an example of the pure arch structure to which the attention of students may be called. This is the "barrel" vault, so called, with arch ribs at intervals projecting three or four inches below the soffit of the vault. Over the square central portion of the corridor this vaulting is groined, giving an interesting variation in the structure. The material used is flat, hard-burned, pressed tile, laid in mortar.

On the first floor opposite the main entrance and in the wing is a lecture room, seating an audience of 400. The floor of this lecture room is level and the seats may be removed. At the west end of the room is a semi-circular bay providing a fireproof booth in which is located equipment for moving pictures. The remainder of the first floor provides four large class rooms, a department library, seminary rooms and the usual offices.

On the second floor the main divisions correspond with the similar divisions in the basement plan. At either end of the building and in the central wing are large drafting rooms. The largest is in the west wing over the lecture hall and is lighted principally from overhead by means of skylights on the north side of the roof. The steel trusses which support this roof are exposed and offer examples of structural work for the student. On this floor there are class rooms, one or two offices and rooms for other purposes, but the principal feature is the provision of abundant drafting room space. Such a large part of the work of the student in civil engineering can best be done on a drawing board, that it is of great importance educationally to provide each student in the upper classes with a desk which he does not share with anyone else. That desk is his headquarters from 8:30 to 5:00 every day. While this plan is somewhat costly, as to both space and

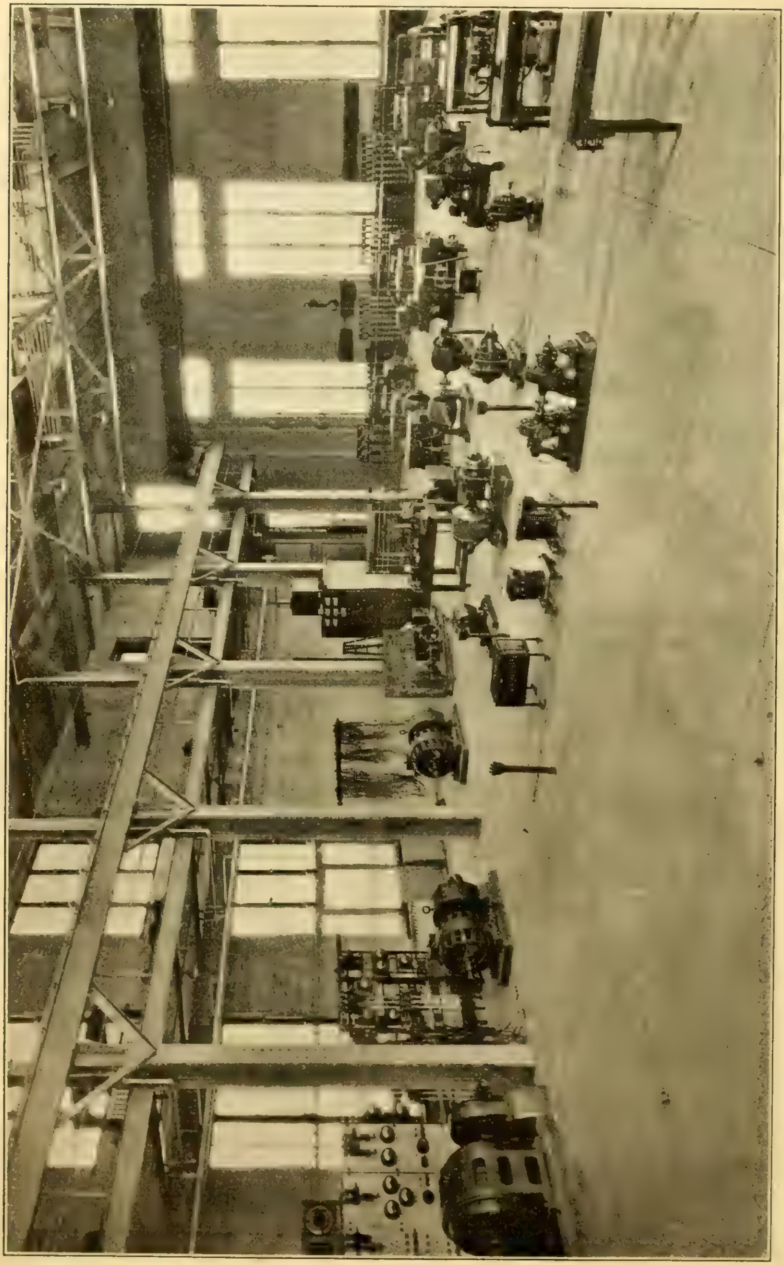

Fig. 6. North End of Machinery Hall.

equipment, it has proved in experience that the results quite justify the expenditure. The attic contains a blueprint room, a dark room and two large, well-lighted rooms, one of which will be used as a museum and the other as headquarters for a student club. Other rooms in the attic provide liberal space to meet the needs of expansion of the work of instruction.

THE POWER PLANT.

The power plant furnishes light, heat and electric power for the entire University group. The building also contains laboratory space for mechanical and electrical engineering, and the power equipment throughout has been especially selected and amplified for its use for the purpose of instruction. The distinct divisions of the power house building comprise a coal storage bunker with overhead supply, a room for steam auxiliaries, the engine and turbine room, a gas engine laboratory, a gas producer room, and a separate laboratory containing a steam locomobile, a complete boiler and engine-dynamo in one unit.

The boiler room contains four Babcock & Wilcox water tube boilers, each of 250 boiler horse-power and an independent steam super-heater. Two of the boilers are fitted with Taylor automatic blast-type stokers with electric airmeter for controlling and measuring the air supply. The other two boilers have Roney non-blast stokers.

The engine room contains one Harrisburg 4-valve reciprocating steam engine-generator unit, one 9-stage Kerr turbo-generator and one single stage Westinghouse turbo-generator, each unit being of 100 K.W. capacity. The generators are compound wound, direct-current machines, working on a 3-wire distribution system at 120 and 240 volts. The auxiliaries room below the engine room contains the feed water equipment, condensing apparatus, steam fire pump, fan equipment for the blast-type stokers and the vacuum pumps for the University heating system. In normal operation the exhaust from the engines and turbines supplies heat for the

University buildings, with suitable provision for supplementing with live steam direct from the boilers.

Special provisions for testing have been made throughout the plant. The switchboard in the engine room is equipped with duplicate sets of bus bars. One set feeds a multiple connected grid resistance, located outside the power house, capable of absorbing 25 per cent. overload on any one of the power units. In this way any unit may be separated from the normal service to the University for the purpose of testing. Also the steam piping is so arranged that a separate boiler may be used for supplying this unit. Complete measuring equipment is furnished both on the electrical and steam sides, so that the entire performance of the equipment under test may be recorded. Means are provided for condensing and weighing the exhaust steam from any one of the units, for measuring the condensing water by use of weir tanks and Venturi meters, for measuring the amount of air supplied to the automatic stoking furnaces, for analyzing the products of combustion leaving the boilers, and for weighing coal and ash.

An interesting feature of the power plant is a small self-contained steam electric unit of about 50 K.W. capacity, installed in an engine room of its own. This type of plant is known as the Locomobile, and is the most economical small steam plant available. During the winter when all of the buildings must be heated, the main power plant is operated and electric power is obtained at relatively low cost. During warm weather, when no heating is required, and when the demand for electric lighting and power is small, the main plant is shut down and the electric load carried by the locomobile. The plant consists of a horizontal, tubular boiler, with an excellent small steam engine mounted directly above and on the boiler, and arranged so that the cylinder is kept hot by direct contact with the hot gases escaping from the furnace within the water space of the boiler. In addition to

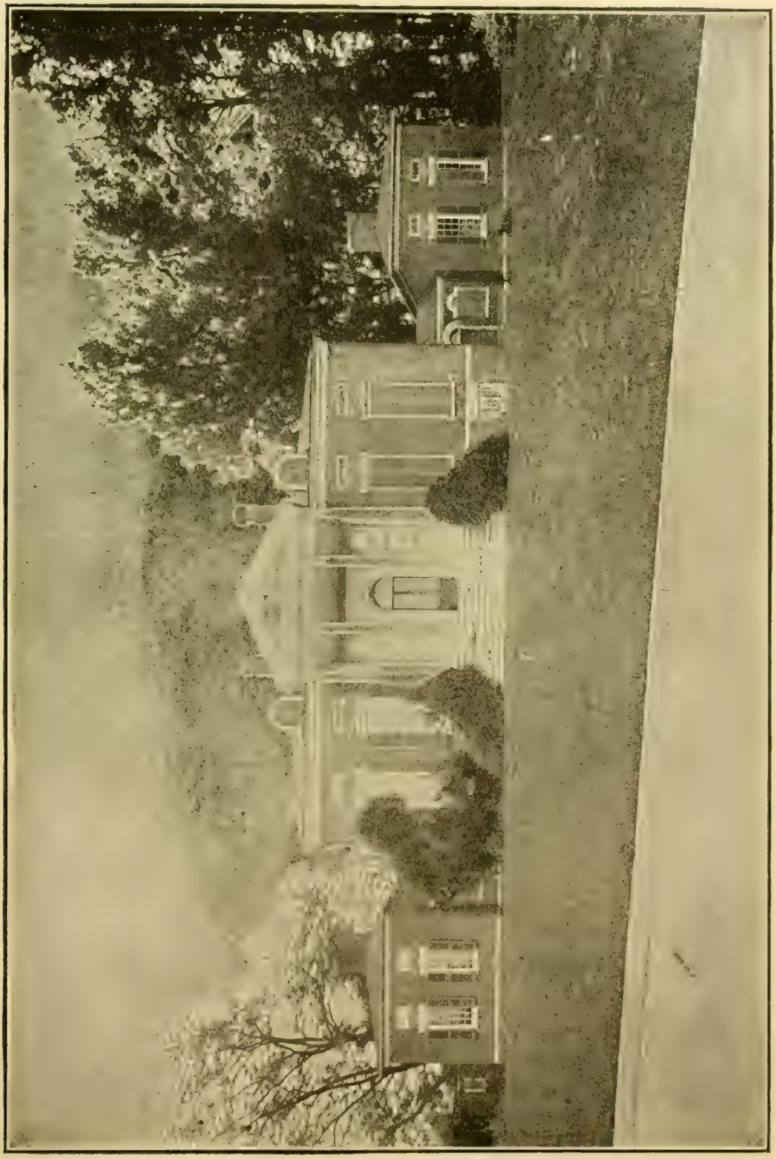

FIG. 7. The Johns Hopkins Club.

its use for this important summer service, this little plant has proven of tremendous value for purposes of instruction. It is turned over in its entirety to the students for complete operation from fuel feed to electric output.

A further interesting feature of the power plant is the provision which has been made for the study of flue gases. Arrangements are made for this study from the air supply to the boilers to the discharge of the products of combustion at the top of the 7 ft. by 150 ft. stack. This is made possible by unusual facilities for the accurate measurement of the amount of air supplied to the automatic stoking furnaces under the boilers. The products of combustion leaving the boiler furnaces and entering the stack may be chemically analyzed, and their amount under different rates of combustion, and with different kinds of fuel, determined by means of special temperature, pressure, and velocity measuring devices with which the stack has been equipped. Two galleries, or platforms, surround the stack at levels of about 50 and 80 ft. above the ground, respectively, and a ladder permits access to these platforms, as well as to the top of the stack. At each platform holes have been provided in the wall of the stack so that the pressure and velocity of the escaping gases can be measured with search tubes, Pitot tubes, etc. Aside from these determinations it is necessary to ascertain the varying temperatures from the bottom to the top of the stack. For this purpose an I-beam is placed across the opening at the top of the stack and by means of suitable attachments to this beam it is possible to raise and lower resistance thermometers and thus to determine the temperature gradient within the stack. A floor fitted with a manhole has been built across the stack just before the entrance for furnace gases and about 6 ft. above the foundation for the stack, thus providing a room under the stack. Manipulation of thermometer leads is accomplished through small holes in the manhole cover.

The various buildings of the University group are connected with the power plant by a system of underground tunnels, through which are carried the various pipe lines and cables for heating, lighting, power, gas, water, fire alarm, telephone, clock and bell service in standard relative location. The tunnels have a minimum head room of 6 ft. and are well lighted throughout. In the ready access to all of the types of service mentioned thus provided, the tunnels constitute an interesting feature in instruction.

DISCUSSION OF REPORT OF COMMITTEE NO. 15, CIVIL ENGINEERING.

BY F. E. SCHMITT,

Associate Editor, Engineering News-Record.

Instruction in the subject of structures at engineering colleges has reached a high standard of excellence during the past several decades of development. Review of its scope and methods would, therefore, be only a task of maintenance-inspection, except for changes that have developed in professional activities and relations. Important changes of this kind have occurred, the writer believes, and particularly in view of the present abnormal conditions a reëxamination of the subject is justified. Collegiate routine has been interrupted to supply army requirements and is not yet fully reëstablished. There is opportunity for replanning courses and revising methods, the first general opportunity of the kind and one that may not be repeated for a long time.

Engineering practice as organized to-day does not bring into action more than a small part of the mental equipment furnished to the students in the present-day engineering courses. Relatively few engineers find occasion to apply directly much of the higher technical knowledge imparted to them. For the majority of technical-school graduates it seems to be true that they do not need all of the engineering education given them; and what is at least equally important, they apparently are not able to show a return on the cost of this education. The compensation paid for many kinds of engineering service—and the term "compensation" might here be taken as including more than simply money—is not above that offered for clerical services of medium grade. It is by no means sufficient to justify the investment which a modern engineering course represents.

In recent conversations with educators of long experience and unquestioned authority of opinion, the writer has been advised that engineering courses should be considered as cultural, not as bread-and-butter courses. Is this a safe view with respect to either the general planning or the detailed elaboration of the engineering course? A technical college is specifically designed to produce technical men for the technical services of modern life. Must it then not be regarded as an instrument of production, as in effect a manufacturing establishment? If so, it should be able to show that its production cost is justified by the value of its product.

But a broader question arises in immediate connection with that of returns. It cannot fail to be noticed that modern industrial organization provides for a very large and increasing proportion of medium-grade technical service, from which responsibility and independence are eliminated as far as possible. Methods have developed in such a way as to reduce in steady progression the number of responsible directing minds, those who are in a position at once to utilize their engineering knowledge and to exercise engineering judgment unhindered by external dictation. The present tendency appears to be still in the same direction. Evidently it is considered desirable at present, in the field of practice, to concentrate rather than distribute responsibility and authority; to adjust engineering operations as fully as possible to standard method and routine; and to rely upon a departmental organization composed of the largest possible number of private directed by the smallest possible number of officers.

Contrasted with forms of organization prevailing in past decades, this modern form affords fewer opportunities for advance to more responsible activity and better compensation. It will be clear that the young engineers, entering the rank of private, have a prospect of promotion in direct line limited to the small number of responsible leading positions. The axiom that there is always room at the top has only limited application under these conditions. Relief is afforded by the transfer of engineers to other but related lines of activity, a branching-out process, but this is only a partial dependence. It remains true that of the school's output of technical men, the larger portion of those who prefer to follow the direct line of engineering service is foredoomed to a life-time of mediocre employ, not better than clerical, in either responsibility or compensation. It is to be remembered that these men belong to a class of special ability, chosen by a process of repeated selection in the successive stages of school life, and even within the technical college itself subjected to a 50 per cent. rejection process.

It may be said, in the light of these conditions, that practice and the schools are not in complete harmony. Engineering practice finds it expedient to use the majority of the engineering material placed at its disposal for routine service, and to limit it permanently to such low-grade function; and it offers a rate of compensation insufficient to justify more than a limited technical training. The schools, however, continue to furnish a high-cost four-year technical product exclusively. The conclusion is indicated that the schools fail to meet the demand of practice. If this is true, the school may have to change its methods.

This is said despite the writer's belief that the methods and tendencies of engineering practice as above suggested are faulty, and ultimately of disadvantage both to the profession and the community. The point is, however, that they exist, that engineering practice can be brought back to another course only very slowly, and that in the meantime the school's duty, to state as well as to student, is to equip the student for the demand, not to equip him for a non-existent demand or to misequip him for the existing demand.

It appears from such considerations that a shorter engineering course, and one giving the student a less refined scientific equipment, may be needed. This thought has been suggested before, but it has failed to find a warm reception. The writer believes that if the idea is regarded in its proper light, not as a merely fanciful modernistic notion, but as the strictly logical consequence of the conditions existing, an actively sympathetic attitude toward it is bound to develop.

Short-course instruction should not disturb the long-course engineering instruction, which must continue to exist alongside of it. The long-course engineering teaching would follow the methods of the present engineering courses except as these might be adjusted so as to coördinate with the short course, and except for possible broadening. Various recent discussions have made evident a general trend of thought in the direction of reducing the more specialized or application phases of engineering teaching, in favor of a return to the teaching of fundamental engineering science and knowledge. Time economy and broadening of scope are jointly involved, and it might well prove to be true that a general engineering course extending over four or five years —the four-year term appears to be nothing other than traditional—and so worked out as to fit the student with the necessary foundation knowledge of his science and art over as broad a range of engineering activities as practicable—is the best suited for meeting the need for highly trained engineers. Such a course, then, would be the companion piece to a series of short courses so laid out as to include technical workers of a lower grade.

Only the specialist, the experienced engineering teacher, can profitably discuss courses of instruction in detail, or for that matter, in their broad aspects. The writer will, therefore, not attempt to make further suggestion as to how the conditions sketched would influence the plan of either the engineering course or the shorter technical course. However, it is obvious that the methods of teaching structures are bound to depend on the length and general plan of the course, and for this reason it appears properly within the scope of the committee's function to consider the possibility of meeting a short-course demand.

Referring more specifically to the committee's subject of discussion, methods of teaching structural designs, the writer desires to express the view that the word ''structural'' should be interpreted as covering all kinds of static structures of the civil engineer's art. Steel frames, retaining walls, dams, and for that matter, ordinary walls, as well as foundations and chimneys, are dependent for strength and stability on the same group of mechanical principles and on the same general knowledge of the strength of materials. Any separation of treatment which is made in the course of teaching as a matter of convenience is likely to diminish the impression of fundamental unity of this subject which the student should acquire and should never depart from. In many college courses these several branches of the subject are dealt with in separate classes, often through separate instructors, and sometimes at periods of time separated half a year or a year. It is the writer's firm belief that the essential unity of the subject should be scrupulously respected in the arrangement of instruction in general and in detail.

If a reshaping of courses is undertaken in the immediate future, there should be opportunity for a return to unity of treatment wherever it has been departed from. The object should be to teach structures, not this and that class of structure. Segregation of the several items of the subject of structures in the teaching course is apt to weaken the student's command of structural principle. Correspondingly, the gain through unity of treatment is far greater than the loss suffered through any slight disadvantage of detail which it may involve.

One further remark on the committee's subject is invited by the word ''design'' in the subject title. Teaching design as a specific subject of instruction seems to the writer mistaken policy. There is necessary occasion for using examples of design in connection with the general teaching of principle, sufficient to give the student a satisfactory acquaintance with the problem of designing. To go beyond this, and give specific practice-instruction in designing, would appear to be reaching out into the field of post-graduate experience.

Teaching principle by teaching design may be proper; that is a question for the expert teacher to decide, and perhaps a primary question. But teaching designing for its own sake appears to be a diversion of college time for purposes that will be as well or better served in the course of the subsequent practical apprenticeship.

LETTER TO THE EDITOR.

MR. F. L. BISHOP,
Secretary, Society for the Promotion
of Engineering Education.
PITTSBURGH, PENNSYLVANIA.

Dear Professor Bishop: I have recently requested twenty experienced teachers, largely in departments of mechanical engineering at some of our best known technical schools, to give me an opinion concerning the number of hours a week a student should devote to his work at college. I asked each of them this distinct question: "Will you check the number of hours a week which you believe should be required of an undergraduate student in engineering: this includes the total time to be spent in class, drawing, laboratory and *study.*" To this question I received the following replies:

Number voting for	0	1	5	5	3	4	0
Hours per week	44	46	48	50	52	54	56

Yours very truly,
L. P. BRECKENRIDGE,
Professor of Mechanical Engineering.

ARMY INTELLIGENCE TESTS AT UNIVERSITY OF FLORIDA.

BY J. R. BENTON,

Dean, College of Engineering.

These tests, as is well known, are intended to measure, as far as may be possible, the native intelligence of a person as distinguished from his acquired knowledge. There were applied here, under the direction of the professor of psychology, and grades were assigned in letters having the following approximate meanings:

A	very high intelligence.
B	intelligence above the average.
C +	high average intelligence.
C	average.
C —	low average.
D	intelligence below the average.
D —	very low intelligence.

"Average" as used above, refers to average of the general population, not that of the particular group under examination. The tests used were identical with those used in the army for testing the intelligence of recruits.

The percentages of students making the various grades were as follows:

	218 College Students of All Kind (Arts and Science, Agriculture, Engineering, Law, Education). Per Cent.	60 Engineering Students. Per Cent.	158 Non-Engineering Students. Per Cent.
A	30.3	40.0	26.6
B	36.7	38.3	36.1
C +	21.1	18.4	22.2
C	11.4	3.3	14.5
C —	0.5	0.0	0.6
D and D —	0.0	0.0	0.0
	100.0	100.0	100.0

The percentages in the second and third of the above columns are obtained from the same students as the first columns, simply separated into groups of engineering and non-engineering students.

The first point of interest is the high general intelligence of the whole student body. C is supposed to represent average intelligence as found among the population in general; but the great majority of the students show higher intelligence—as they should, if they were properly selected from the population as a whole. Only one received a grade as low as C —, and he was out of health, and had to leave college shortly after the test.

The next point of interest is superiority of intelligence shown by the engineering students as compared with the others. While the number (60) of engineering students tested was not large, it was large enough to make it improbable that the high standing in intelligence was due to the accidental presence of a few men of unusual ability. I am not able to offer an explanation why our engineering students made a better showing in the intelligence tests than the others. It may be that engineering appeals more to men of superior intelligence than other studies; it may be that in our college of engineering we have been more successful in weeding out the unfit than in other branches of the institution.

CORRECTION OF FEBRUARY NUMBER.

In the discussion of General Black's address on page 238 of the February number the remarks attributed to R. C. MacLaurin are an error. These were made by W. S. Franklin.

CORRECTION OF MARCH NUMBER.

On page 259 of the March number, the name of O. J. Ferguson appears under "Names to be removed from year book due to deaths and resignations." This is an error as Professor Ferguson has not and does not wish to resign.

LIEUT. WILLIAM H. STUART.

The American Red Cross is using every effort to aid in locating Lieut. William H. Stuart, son of Duncan C. Stuart, of 12 Maple Street, Oneonta, New York, and will appreciate any information that can be secured relative to his whereabouts.

Lieut. Stuart is 27 years of age. He arrived from overseas service on January 13 and went to Washington, where he was given his discharge. He returned to New York and was last seen in that city January 18, at 7:30 P.M. He is a graduate of Colgate, Class 1914, and took two years' post-graduate work at Brooklyn Polytechnic Institute. He is 5 feet 8 inches tall, has dark brown hair and blue eyes and a ruddy complexion. He has a brown mole on the left side of his nose. He has three gold service chevrons on his sleeve indicating eighteen months' service overseas, if in uniform. He was wearing when last seen spiral puttees and not the customary leather ones for officers.

Information relative to him may also be sent to D. C. Stuart, 13 Maple Street, Oneonta, New York, or Thomas Blizard, Chief of Police, Oneonta, New York.

EDITORIAL.

In this number of ENGINEERING EDUCATION appears an article in regard to The Johns Hopkins University. At the time the School of Engineering was established at this university, a commission composed of educators and engineers made an exhaustive study and founded a curriculum based upon a much greater per cent. of humanities than was found in most of the engineering courses then in existence in the country. This was fully in accord with the character of The Johns Hopkins University. Since then, however, with the experience gained in the war, the courses have been considerably modified in order to bring into the earlier years more concrete illustrations of engineering. This is also in accordance with the report of the Joint Committee on Engineering Education. It is interesting in this connection to note that the proposed revision of courses in the Massachusetts Institute of Technology eliminate modern language from all courses except architecture and chemistry, French being required in the former and German in the latter. Here, as in the case of The Johns Hopkins University, subjects have been moved back into the freshman year. At the 1919 meeting such subjects as the above and many others will form the basis for much discussion both at the meetings and among individuals at other times. This surely is the opportune time for teachers of engineering to meet for discussion and assist in the solution of these new problems.

The Bureau of Education at Washington through its Department of Commercial Education, has called a conference of those interested in commercial education, especially in its relation to engineering, at Washington two days previous to the meeting of this society; that is on June 23 and 24. This society was represented at the preliminary conference by Dean

W. E. Mott, and the society is coöperating with the Bureau of Education in arranging the program.

The American Council on Education meets in Washington on May 2 to discuss a number of problems among them the following:

The adoption of a permanent constitution.
The election of a salaried executive for the Council.
The question of the establishment of headquarters at Washington or New York.
The annual election of officers.
Report of the committee to consider the relation between the Council and the recently established Institute of International Education; and also to the American University Union.

The society is represented on the American Council on Education by F. L. Bishop, F. W. McNair and C. R. Mann.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. IX LANCASTER, PA., JUNE, 1919 No. 10

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FRANK JOHNSON GOODNOW.

President, The Johns Hopkins University.

President Frank Johnson Goodnow was born in Brooklyn, New York, in 1859. He entered Amherst College in 1875 and was graduated with the degree of bachelor of arts in 1879. He entered the Columbia University Law School in 1881 and obtained the degree of bachelor of laws in 1882. In the same year he was admitted to the bar of the State of New York and began the practice of his profession in the City of New York. In 1883 he was offered a position to teach administrative law in the newly established School of Political Science of Columbia University and was given a year's leave of absence to study in Europe. In the year 1883–84 he studied at the École Libre des Sciences Politiques at Paris and the University of Berlin.

President Goodnow began his teaching career at Columbia in the autumn of 1884 and remained there continuously until 1914. During that period he contributed many articles on subjects connected with administrative law and wrote a number of books on various phases of public law.

He was also a member of the commission which drafted the present charter of the City of New York and a member of President Taft's Commission on Economy and Efficiency, obtaining leave of absence from Columbia University to take up his work at Washington. He was later appointed legal adviser to the government of the Republic of China and spent nearly two years in Pekin, whence he returned to this country to accept the presidency of The Johns Hopkins University in October, 1914. Since his assumption of administrative work at the university he has continued his activity in public affairs. In 1915 he was appointed chairman of the Maryland

FRANK J. GOODNOW,

President, The Johns Hopkins University.

Commission on Economy and Efficiency. This commission among other things drafted an amendment to the Maryland Constitution, subsequently adopted, which made provision for an executive budget and has been extensively copied by other States.

JOHN F. HAYFORD.

PRESIDENT, SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, 1918–19.

John F. Hayford, C.E., Sc.D., was born on a farm near Rouses Point, N. Y., May 19, 1868. His ancestors for several generations back were Americans engaged in farming or in mechanical pursuits. He graduated from Cornell University in June, 1889, and immediately assumed his duties with the Coast and Geodetic Survey in Washington continuing this work for seventeen years between 1889 and 1909, with an interruption of three years, 1895–98, when he was an instructor in civil engineering at Cornell University.

During the period 1898–1909, while doing the executive work incidental to the fact that he was in charge of both the field and office work of the triangulation, precise leveling, and astronomic work of the survey, he was also active in improving methods and research work. During that period the methods of primary triangulation and of precise leveling were so changed as to greatly increase the rate of progress and diminish the unit cost while maintaining the standard of accuracy at or above its former level. A new precise level and a new portable transit micrometer instrument for determining differences of longitude, which were devised under his general direction, have proved to be epoch makers. Extensive researches by him intended to determine the reasons for prevailing disturbances observed over the whole earth in the direction and intensity of gravity culminated in decided improvements in the methods of determining the shape and size of the earth and furnished decisive proof that the condition called isostasy exists. This proof shows definitely that the rocks underlying the United States to a depth of possibly as great as 75 miles have a smaller average density than the rocks under the adjacent oceans.

JOHN F. HAYFORD,

President, Society for the Promotion of Engineering Education.

Since 1909 Mr. Hayford has been the director of the College of Engineering at Northwestern University, which he characterizes as a new college in which the main emphasis is put on quality first.

He has been connected at various times with fixing four international boundaries, United States and Mexico, United States and Canada, United States and Alaska, and Costa Rica and Panama. He has been a member of the National Advisory Committee for Aeronautics since 1915. During the war Mr. Hayford has been in Washington about three fourths of the time on war problems as a rule connected with aeronautics.

Director Hayford first became active in the Society in 1905 and 1906 when he presented papers entitled "Opportunities for Engineers in the Government Service" and "Why not Teach about Men, the Most Difficult Tools an Engineer Uses?"

ANNOUNCEMENT AND PRELIMINARY PROGRAM OF THE 27TH ANNUAL MEETING, THE JOHNS HOPKINS UNIVERSITY, HOMEWOOD, BALTIMORE, MD.

11:30 A.M.—Meeting of the Council at Johns Hopkins Club.
2:00 P.M.—Opening Session,

President Hayford Presiding.

Address of Welcome. Frank J. Goodnow, President, The Johns Hopkins University.

Response. John F. Hayford, President of the Society.

Report of Special Committee on the report of the Joint Committee on Engineering Education. W. E. Mott, Chairman. Chairman.

The Case System for the Study of Law; What it is, and its Bearing on Engineering Education. C. F. Allen, West Roxbury, Mass.

Mental Tests for Engineering Students. Walter V. Bingham, Carnegie Institute of Technology, Pittsburgh, Pa.

Report of Committee No. 15, Civil Engineering. A. H. Fuller, Chairman.

Highway Transport Engineering. A. H. Blanchard, President, National Highway Traffic Association, New York City.

Appointment of Committees on Resolutions and Nominations.

8:00 P.M.—Annual mixer meeting at Baltimore Country Club.

THURSDAY, JUNE 26.

9:00 A.M.—Meeting of the Council.

9:30 A.M.—Second session.

Effect of the War on Engineering Education. Discussion opened by Anson Marston, The Iowa State College.

Report of Committee No. 8, Admission. E. F. Coddington, Chairman.

Report of Committee No. 10, Mathematics. L. C. Plant, Chairman.

Report of Committee No. 11-A, Physics. G. W. Stewart, Chairman.

Report of Committee No. 12, English. C. W. Park, Chairman.

The Unconscious Plagiarist. G. I. Mitchell, University of Pittsburgh.

12:00 M.—Informal luncheon for convention in Machinery Hall.

2:00 P.M.—Third session,

Military Training in Engineering Schools. Col. F. J. Morrow, Chairman, Committee on Education and Special Training of the War Department. Charles S. Howe, President, Case School of Applied Science.

Report of Committee No. 16, Mechanical Engineering. O. A. Leutwiler, Chairman.

Teaching Safety in Engineering Schools. George W. Case, University of Pittsburgh.

Report of Committee No. 17, Electrical Engineering. C. Francis Harding, Chairman.

Report of Committee No. 18, Mining Engineering. F. W. Sperr, Chairman.

Report of Committee No. 20, Standardization of Technical Nomenclature. John T. Faig, Chairman.

7:30 P.M.—Annual dinner at Baltimore Country Club.

Presidential Address: "Reflections of an S. P. E. E. President." President John F. Hayford.

FRIDAY, JUNE 27.

9:00 A.M.—Meeting of the Council.

9:30 A.M.—Fourth Session.

The Society for the Promotion of Engineering Education. A Survey of its Past and a Reconnaissance of its Future. George R. Chatburn, Past President.

The Vitalizing Principles in Education. Edward J. Kunze, Cooper Union.

Vocational Correlation. O. J. Ferguson, University of Nebraska.

Report of the Treasurer.

Report of the Secretary.

11:00 A.M.

Leave The Johns Hopkins University by street car, taking train at Camden Station at 12:00 M. for Annapolis.

1:15 P.M.—Luncheon at Carvel Hall.

Inspection of the United States Naval Academy and the Engineering Experiment Station.

6:00 P.M.—Take train for Baltimore.

8:00 P.M.—Informal smoker, location to be announced at meeting.

SATURDAY, JUNE 28.

9:00 A.M.—Meeting of the Council.

9:30 A.M.—Fifth session.

Report of Committee on Resolutions.

Report of Committee on Nominations.

Election of Officers.

Symposium on Changes in Courses. The New Course at Tufts College, Gardner C. Anthony, Tufts College.

Report of Committee No. 11-B, Chemistry. R. M. Bird, Chairman.

Report of Committee No. 13, Mechanics and Hydraulics. O. H. Basquin, Chairman.

Report of Committee No. 14, Economics. C. C. Williams, Chairman.

12:30 P.M.—Adjournment.

MEETING PLACE.

Mechanical and Electrical Engineering Building, The Johns Hopkins University, Homewood, Baltimore, Md.

REGISTRATION AND INFORMATION.

The place of registration and general information will be in one of the rooms of the Mechanical and Electrical Engineering Building.

RECREATION AND EXCURSIONS.

The Local Committee has arranged a luncheon for the first meeting of the Council at the Johns Hopkins Club at 12:30 P.M., Wednesday, June 25. The annual mixer meeting will be held at the Baltimore Country Club, Wednesday evening at 8:P.M., and the annual dinner at the same place Thursday evening at 7:30 P.M. This dinner will be $3.00 per plate. Friday afternoon has been set aside for a trip to the U. S. Naval Academy and the Engineering Experiment Station. Street cars will leave the University at 11:00 A.M. in order to make connections at Camden Station with the train leaving there at 12 M. Luncheon will be served at Carvel Hall, Annapolis, at 1:15 at 75c. per person. There will be an informal smoker on Friday evening at 8:00 P.M., the location to be announced at the meeting.

Headquarters will be established at The Rennert. The rates are single rooms without bath, $1.50 to $2.50; with bath, $2.50 to $5.00, single; second person in room $1.50 additional.

Other hotels and rates are:

Southern Hotel—$3 and $4 per day, single; $5, $6 and $7 per day, double. Every room has bath.

Belvedere Hotel—$3 and $4 per day, single; $5, $6 and $7 per day, double.

The Emerson—Rooms without bath, $3.50 and $4; with bath, $4 and $4.50. Room with bath, two persons, $7 and $7.50 per day.

LOCAL COMMITTEE.

John B. Whitehead, *Chairman.*

COMMITTEE ON ROOMS AND MEALS.

A. G. Christie, *Chairman,*
J. H. Bringhurst, J. C. Smallwood,
M. W. Pullen.

COMMITTEE ON RELATIONS WITH NON-MEMBERS AND ENTERTAINMENT OF VISITING LADIES.

C. J. Tilden, *Chairman.*
J. H. Gregory, J. E. Greiner.

COMMITTEE ON ARRANGEMENTS IN MECHANICAL AND ELECTRICAL ENGINEERING BUILDING.

J. B. Whitehead, *Chairman,*
A. G. Christie, W. B. Kouwenhoven,
J. C. Smallwood, M. W. Pullen.

COMMITTEE ON EXCURSIONS AND ENTERTAINMENT.

C. J. Tilden, *Chairman,*
L. A. Doggett, W. B. Kouwenhoven,
J. B. Scarborough, R. E. Root,
C. A. Styer.

OFFICERS FOR THE 1919 MEETING.

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PRELIMINARY REPORT OF SPECIAL COMMITTEE ON THE REPORT OF THE JOINT COMMITTEE ON ENGINEERING EDUCATION.

W. E. Mott, *Chairman,* Carnegie Institute of Technology; C. S. Howe, Case School of Applied Science; L. M. Hoskins, Palo Alto, Calif.; T. U. Taylor, University of Texas; F. H. Constant, Princeton University.

The members of the Special Committee appointed "to make a study" of Dr. Mann's report have been unable to hold a meeting because of their wide geographical distribution. It seems wise to indicate in advance of the Baltimore meeting what the nature of our report will be and the chairman is therefore taking the responsibility of publishing at this time what may perhaps be regarded as a preliminary or progress report. The members of the Society who have read and discussed "The Study of Engineering Education" will realize that unanimity of view regarding the same is impossible even in a committee of five.

The purpose of presenting the report in the form of a set of resolutions is to concentrate discussion upon certain definite questions raised by Dr. Mann. It is not assumed that other important phases of the "study" should not be discussed by the Society and doubtless individual members will propose some of these other questions for debate.

Again, the six points raised are those which could perhaps be adopted in any given institution with the least amount of rearrangement of administrative and teaching machinery and may therefore be discussed on their intrinsic merits, or the reverse. We are very apt to oppose a new pedagogic proposition because we feel it will not work under our own particular local conditions.

If the sub-committee report serves to concentrate discussion and hasten action by the Society upon at least some of the vital questions raised by Dr. Mann its purpose will have been attained.

The *form* of the following report is agreed to by a majority of the sub-committee and the six items are also subscribed to by a majority, though not always by the same individuals.

It must, therefore, be explicitly stated, and understood, that the individual members of the committee are not committed to vote affirmatively upon all six items of the report, or even that all hold the view that each of the points raised should be discussed as presented.

REPORT OF SPECIAL COMMITTEE "APPOINTED TO MAKE A STUDY OF THE REPORT OF THE JOINT COMMITTEE ON ENGINEERING EDUCATION, AS PRESENTED BY DR. C. R. MANN, AND REPORT TO THE SOCIETY."

WHEREAS, The experience of engineering educational institutions, especially during the period of the war, indicates that many of the practices now adopted in the training of engineers are susceptible of modification and improvement, and,

WHEREAS, The Society for the Promotion of Engineering Education should do everything possible to advance the cause of engineering education by the establishment of standards when necessary and by active coöperation with schools, colleges and universities in carrying forward educational research and experimentation, and,

WHEREAS, "The Study of Engineering Education," prepared by Dr. Charles R. Mann, and presented before this Society by the Joint Committee on Engineering Education, has set forth the main points at issue in such plain and forceful language that engineers and educators alike have given this report most careful consideration, therefore, be it

Resolved, 1. That this Society, through its Committee on Admission, or otherwise, recommend that psychological "objective," "trade" or other similar tests be given to all students after admission to engineering courses of study and that the ratings thus obtained be compared with their subsequent scholastic progress.

2. That this Society should recommend the establishment and adoption of standards, or tests, whereby the mental growth of students and their power to assimilate and coördinate knowledge may be evaluated in terms easily recognizable by both educators and employers, such standards to be applied during and at the end of the course of study.

3. That schedules of study for engineering students should call for not more than forty-eight (48) work hours per week (including recitation, laboratory, field work and home preparation), this time to be divided among not more than five (5) subjects which require preparation outside of class exercise.

4. That all engineering students should be required to pursue courses which will prepare them for administrative duties and for responsible and effective citizenship. These courses should involve constant training in the use of English, both written and oral.

5. That a committee be appointed, to study and report to the Society, the most desirable method or methods, of carrying on shop work for students pursuing engineering courses, so that such shop work shall motivate as many of the courses of study as possible.

6. That the Society should coöperate with the national and other engineering societies, with a view to establishing a classification of the work, or positions, including specifications as to necessary preparation and qualifications, into which our engineering graduates enter, so that undergraduate students would thus have a clearer understanding of the work for which they are preparing themselves and instructors have before them a constant reminder of the main purpose of their teaching work.

DEPARTMENTAL AUTONOMY.

BY W. H. RAYNER,

Associate in Civil Engineering, University of Illinois.

In any complex undertaking which involves the efforts of many individuals we acknowledge at once the value of sympathetic coöperation made effective through coördination in reaching a common goal. Our experience in conducting the war through many war boards, bureaus, and commissions has given a new meaning to the word "coördination." In so vast an enterprise with so many sources of authority it is small wonder that confusion and waste accompanied our notable achievements. We can easily appreciate the point of view of those who sought to coördinate the efforts of all departments by urging the President to centralize authority and responsibility in one supreme war board.

In our educational institutions it so happens that we have in each university many departments which have grown up parallel to and quite separate from each other, and on account of this condition many persons believe the work of the schools is very seriously injured. In fact, the Joint Committee on Engineering Education of the National Engineering Societies has made particular mention of this subject in their introduction to Professor C. R. Mann's report on "A Study of Engineering Education."

The vital question seems to be whether or not, and how far, a given department should yield its control over courses in compliance with a policy of coördination with other departments, and it will be our purpose in the following paragraphs to present some of the arguments both for and against a change in the status quo.

It will be helpful first to quote the brief description given by Professor Mann of the two types of organization in our engineering schools which exemplify the conditions under discussion. The two plans are designated as ''autonomous-department'' and the ''Cincinnati'' plans, and are described briefly as follows, pp. 29, 30: under the former plan, ''the choice of subject matter, texts, and methods of instruction in each subject is left entirely to the department concerned. For example, if three hours a week is assigned by the faculty to English, the Department of English may use the time in any way it likes. Each department is treated as an expert in its own line, and this departmental autonomy is carefully preserved by common consent.''

''At Cincinnati the engineering school has its own department of English, mathematics and foreign languages; and the departments of physics and chemistry, though organized under the faculty of liberal arts, are represented in the engineering faculty by the instructors who teach the engineers. The faculty thus constituted meets every Saturday morning for a systematic study of its educational problems.'' ''A syllabus stating the objects, the methods, the subject-matter, and the mechanism of the school as a whole was prepared by the dean and discussed at length by the faculty. After many changes and amendments the syllabus was finally adopted as an adequate expression of the basic conceptions toward which the school as a whole is working.'' Additional features are mentioned by the report which illustrate the completeness with which coördination applies to all the departments in the university.

The main arguments in favor of the autonomous-department plan are three:

First, this type has the advantage of administrative feasibility; or stated negatively, it would be very difficult, if not impossible, in some cases, to provide the separate sections necessary to differentiate chemistry, for example, to meet the needs of each of several engineering departments, architectural, civil, mining, mechanical, etc.

The second argument favoring this type of organization is the idea that only a broad foundation of fundamental principles is adequate to equip our students to cope successfully with any situation that may arise. Moreover, each department, *e. g.*, the chemistry department, is deemed to be the only competent authority to say what those principles in chemistry are and how they shall be presented; therefore that department logically should organize the courses to be given all beginning students in chemistry.

The third argument may be stated somewhat as follows: thorough preparation is needed in certain fundamentals not only as providing a thoroughgoing basic preparation, but for the contribution they make to breadth of view, to a disciplined mind and to general training. This argument states that such subjects as mathematics, chemistry, physics, mechanics, etc., are peculiarly pregnant with possibility for developing such qualities as observation, attention, concentration, logical reasoning, etc., which go to make up general intelligence in the field of engineering. These subjects are the especially adapted apparatus by which intellectual muscle is developed and mental power trained.

These arguments then lead to the conclusion that coördination between departments, at least so far as say freshman and sophomore subjects are concerned, is bad and autonomy should be preserved.

The arguments supporting more complete coördination may be stated best perhaps in refutation of the arguments given above.

First, administrative difficulties may be great, but, where possible, they are to be removed rather than feared.

Second, the proponents of coördination would ask regarding the need for a broad foundation, just what is meant by this argument. In engineering construction while the matter of an adequate foundation is exceedingly important yet great care is exercised that it shall not be broader than the superstructure will require. Anything more than that is considered to be sheer waste of energy and materials. So it becomes a matter of adjustment and careful consideration as to just what the dimensions and needs of the foundation shall be and a department may claim on this argument that it is the more competent to prescribe the content and extent of the foundation courses for its own students.

Third, as regards the idea that certain subjects are peculiarly beneficial in training the mind, the answer would be made that here is a fundamental issue which requires some analysis of the nature of education itself. The notion that part of the function of education is to discipline the mind, to develop intellectual powers, or has for its aim the "harmonious development of all the powers," is based on one of two theories, (*a*) faculty psychology, or (*b*) transfer of training.

The former theory states that the mind is composed of rudimentary or undeveloped faculties, such as memory, attention, concentration, logical reasoning, etc., and that it is the duty of education to get at the business of training these faculties for life's endeavors. This theory has now been abandoned by all psychologists and is not worthy of further notice here.

The conception of transfer of training states that certain qualities of mind developed in the study of one subject will carry over into other activities. Thus the study of mathematics will develop powers of abstract thinking, logical reasoning, etc., etc., and these qualities will carry over and function in engineering, law, medicine, or economics. This idea has many advocates, but they all agree that the amount of transfer is very much more limited than is generally supposed. So Thorndike concludes "that a change in one function alters any other only in so far as the two functions have as factors identical elements." *E. g.*, improvement in addition will improve arithmetic because there are identical elements in both.

One of the most recent and authoritative statements on this subject may be fairly interpreted by the two following quotations:*

"An appreciation of mathematical or syllogistic cogency, for example, may leave other forms of reasoning untouched; devotion to truth in the laboratory is no guarantee of open-mindedness and impartiality of judgment in other fields, and the punctilio of card-playing and duelling warrants no inference with regard to conduct in general.''

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* Bode, B. H., *School and Society*, January 11, 1919.

''Taken as a mechanical or automatic transmission, there is no transfer of training; taken as a conscious activity, transfer of training becomes synonymous with intelligent behavior.'' This means that we may not rest on the supposition that every kind of training is good for the mind in general, but that education is effective in so far as it provides rich and adequate concepts regarding the factors with which the student must deal when he meets a new situation, and mental training afforded by the study of any given subject is effective in other fields only in so far as these concepts have been developed in pursuance of definite aims.

Or if we take an example from the development of an athlete we may perhaps find the analogy useful. If there is no particular end in view, if our athlete is not training for any particular activity it will not make much difference what apparatus he uses; dumb bells, Indian-clubs, chest weights, parallel-bars, all will be equally good. But if he is training to be a pole-vaulter, a runner or a base-ball player he will not waste much time or effort on gymnasium apparatus in the ''harmonious development of all his powers.'' His coaches know pretty definitely what muscles and coördinations need training and these are the ones he cultivates and this development takes place mainly in doing the very thing in which he hopes to excel.

In fact, there is known to be such a thing as interference in training. Suppose a man learns one keyboard on a typewriter and then changes to another. He is worse off than had he never seen a typewriter. And also, the development of certain muscles in the training of an athlete are consciously avoided because of their interference with the best development of the requisite powers for the end in view.

It is this principle which may account for the complaint that the college trained man is egregiously lacking in common sense. In a new situation he is helpless unless he can find a text-book formula to fit the case. In other words, it is possible that our educational process may distinctly injure or interfere with the proper development of valuable native ability.

If these notions about transfer have any validity here, it means that a great deal of the alleged value of certain subjects to provide general training, discipline, etc., simply does not exist.

On the positive side it means that it is simply good sense to educate our students as definitely as possible following clearly defined aims at every step. The resulting economy of time and effort would provide opportunity for far more intensive, extensive and thoroughgoing development in the chosen field; or more time and opportunity would be provided to work out the complex connections which the student's field of endeavor has with life. Thus the real meaning and significance of a man's vocation to the community and nation might be made more evident, and to that extent he would be a more intelligent and cultured man.

From these arguments, then, each department is the body of experts, whose proper function it should be to prescribe or at least approve the content and aims of courses to be provided for its students.

REPORT OF COMMITTEE NO. 13, MECHANICS AND HYDRAULICS.

Topic: Main Objectives in Teaching These Subjects.

O. H. Basquin, *Chairman,* Northwestern University; J. E. Boyd, The Ohio State University; C. H. Burnside, Columbia University; H. F. Moore, University of Illinois; C. I. Corp, University of Wisconsin.

1. The courses to which this report particularly relates are those of mechanics, strength of materials, and hydraulics; portions of the report may be considered to be of more general application. Preceding mechanics, the student has had an introduction to this subject as a part of general physics; he has had a course in calculus, or takes that study along with mechanics.

2. In each of the three courses considered, one of the main objectives is to give the student a working knowledge of fundamental facts and principles. An engineer needs a working knowledge of essentials rather than a superficial knowledge of a wide range of information. One who is not confident of the essential accuracy of his knowledge does not readily gain the confidence of others, and rarely maintains his own self-respect.

3. The course in mechanics makes extended use of facts and principles which the student should have acquired in physics, calculus, geometry, algebra, and arithmetic. A first duty of the instructor in mechanics is to put the essential parts of these prerequisite subjects into working order; and this instructor should not look upon his task as that of doing another man's work. One can rarely secure thorough knowledge of any fact on first meeting it; the early courses cannot give the wealth of illustration and the new points of view that are available in later courses; and repetition at intervals is a particularly efficient method of learning.

4. Similar suggestions might be made with respect to strength of materials and to hydraulics; in fact, with respect

to almost any course of an engineering program. The objective is to put the essential facts and principles into such form that they can be used by the student with readiness, accuracy, and certainty.

5. The student must become proficient in the solution of problems. Under proper circumstances, it is believed that some of this problem work should be done under supervision, for the purpose of giving the student a start in logical thinking and in orderly, accurate, and economical methods. This suggestion is based upon the principle that it is easier to start a right habit at the beginning than to correct a wrong one. The chief danger in adopting this suggestion is that the instructor may not give the proper kind of supervision: he must not be dictatorial but must develop initiative; his work is to make the student do his own thinking in a proper manner—not to think for the student; when the student has acquired this ability he needs no further supervision.

6. Mechanics is an experimental science; experimental work should accompany each course under consideration. A blind person cannot understand the theory of painting because he cannot experience the sensations of color. In a similar way, a student cannot comprehend mechanics unless he can experiment, because it is only through experiment that he obtains the fundamental concepts upon which the subject is based. The student needs experiments to illustrate in a concrete way some of the important derived facts that are developed in theory, to show their degree of accuracy, and to point out their limitations. In this connection it is to be noted that such experiments, to be most useful, should be so correlated with the class instruction that these concepts and illustrations will be given to the student by the laboratory work at appropriate stages in the development of theory in the class room.

7. The successful engineer is an accurate observer and he draws conclusions from data directly obtained from observed facts. Laboratory work is particularly useful in developing habits of observation on the part of the student. A text-book

problem gives a more or less definite key to its solution through its selection of data: this is not the case with problems that arise in the laboratory; here the student has a chance to apply his knowledge to facts that he obtains through his own selection and observation. The instructor who deprives the student of this experience by giving too minute instructions, denies him an excellent opportunity to develop that resourcefulness and straight-forward thinking, which an engineer must have when facing practical problems.

8. Since an act of observation is not complete until the student has recorded and explained what he has observed, the report is an essential part of laboratory work. It serves to fix the observed facts in the student's mind in an orderly sequence and in an emphatic manner, while it enforces thought upon unselected data. While the report should be in good form, the student should be encouraged to limit its contents to essential matter.

9. Many of the principles of engineering are based upon assumptions, while approximations are often made in analyses. Since the student should be taught to think logically, it is of prime importance that the instructor make a sharp distinction between fact and assumption, between strict analysis and approximation. In reaching conclusions, analyses should be used whose refinement is appropriate to the data obtainable, and the limitations of the conclusions should be recognized. These suggestions relate to the development of intellectual integrity; it is not suggested that these matters be given such undue prominence as to confuse the student, but it is highly important that the instructor appreciate them and make them clear to the student on appropriate occasions.

10. The engineer needs a fluent command of good and forceful English. This is largely a matter of habit, and its development can be brought about most effectively by the coöperation of all instructors to this end. Every student should acquire habits of punctuality in the prompt completion of every duty, of numerical accuracy of acceptable grade, of the presentation of work in good form, and of economical methods of

study. Such habits improve the efficiency of instruction and form the beginning of character development. All instructors should coöperate in their formation.

11. Every instructor should regard it as his duty to make his course interesting—not easy or amusing. A course is interesting to a student if he feels that the value that he is able to get from it is large in comparison with the effort that it costs. Interest makes the student put forth his best efforts with pleasure, it makes him observant of cases that arise in his daily life where his knowledge gives new insight, and it tends to make him continue to be a student of the subject after he has left the instructor's guidance. With this in view, the instructor should specialize in making explanations in simple language, using concrete illustrations that will be appreciated by every student. Interest may be stimulated by letting the student know in advance how he will use a principle about to be studied, by allowing the student to do a part of the thinking in the development of a principle, and by so arranging the assignments that the student will feel that he has made some definite worth-while acquisition from each assignment.

12. The instructor should seek to develop in the student such mental attitudes as will assist instruction and be of permanent value to the student. The spirit of coöperation should characterize intercourse between instructor and student. The group system in laboratory work and in field work may be used to develop both coöperation and leadership. Uniformly thorough work coupled with encouragement of the student's initiative will give him confidence in his knowledge and in his ability to apply it. Insistence upon the full performance of every assignment, accompanied with extreme care on the part of the instructor to make appropriate assignments, will tend to develop in the student the feeling that he can and must accomplish every duty set before him. The instructor should understand the relations which an engineer should sustain to the community, to the state, and to civilization, and, when the occasion warrants, he should make

his students feel the necessity of assuming these obligations.

13. It is believed that much good may result if the instructor gives due consideration to the following quotation from Thorndike's ''Principles of Teaching'': ''The efficiency of any profession depends in large measure upon the degree to which it becomes scientific. The profession of teaching will improve (1) in proportion as its members direct their daily work by the scientific spirit and methods, that is by honest, open-minded consideration of facts, by freedom from superstitions, fancies or unverified guesses, and (2) in proportion as the leaders in education direct their choices of methods by the results of scientific investigations rather than by general opinion.''

SUMMARY.

I. *Objectives of Knowledge.*

1. *Mechanics.*—Thorough training in fundamental facts and principles, enabling the student to recognize the mechanical principles and the mathematical treatment appropriate for simple problems for which he takes his own data.

2. *Strength of Materials.*—Working knowledge of the common theory of elastic action, and its application to the simple members of structures and of machines, paying attention to assumptions in theory and to limitations when conclusions are applied to actual materials.

3. *Hydraulics.*—Thorough understanding of the principles of hydrostatics and of fluid motion, with simple applications so arranged as to bring out the relations between theory and experiment.

Each course should give a thorough drill in all ground covered, using oral recitations, blackboard demonstrations, informal written quizzes, problems, and laboratory work.

II. *Objectives of Habit.*

Certain general habits on the part of a student should be encouraged by all his instructors; among these may be mentioned (1) intellectual integrity, (2) good English, (3) economical methods of study, (4) punctuality, (5) completion of assignments, (6) numerical accuracy, and (7) presentation of work in good form.

III. *Objectives of Attitude.*

For the purpose of making the student's work more efficient and to make him a better man, every instructor should seek to develop in him certain mental attitudes, such as (1) interest in his work, (2) coöperation with his associates, (3) leadership, (4) self-confidence, and (5) duty.

It is believed that the instructor should be a student of the teaching process.

MACHINE WORK AT THE OHIO STATE UNIVERSITY.

BY W. A. KNIGHT,

Associate Professor Machine Shop Practice.

It is the purpose here to give, somewhat in detail, the method of conducting machine work at The Ohio State University. The system has been in operation now five years, long enough for the glamor incident to trying out a new scheme to wear off, and to view the work in the light of practical experience. It is believed that the plan has merit and can readily be adapted to most college shops. Naturally, all of the questions that may arise in connection with the operation of the plan, can not be answered within the scope of an article like this, but sufficient detail will be given to enable one interested to form a fairly correct estimate of its soundness and practicability.

Students in electrical and mechanical engineering are required to take six hours of machine work per week for a school year. Of this time five hours per week are spent in the shop and one hour per week in the class room for lectures and recitations. The year is divided into the usual two semesters, the first of which is devoted to what is scheduled as elementary machine work, and the second to advanced machine work.

First Semester's Work.

During the first semester the student, after a couple of preliminary exercises on straight and taper turning, makes complete a small emery wheel stand. The making of this stand furnishes exercises in the fundamental operation of turning, boring, reaming, threading, chuck and face plate work, drilling, tapping, babbiting, scraping in bearings, and some little planer and milling machine work.

While the work is not on a productive basis in the sense in which a product is regularly placed on the market, yet it is, in the sense that every piece is made with the definite object in view of using it in the finished machine; and, further, the product is complete in itself and has marketable value when finished. Each student finishes his own grinder, and although certain standards are maintained, the work is in no sense interchangeable. The work is individualistic. The methods followed are in the nature of machine building rather than manufacturing. However, attention is here directed to the fact that the making of a complete piece of apparatus such as the grinder stand, appeals strongly to the student's constructive desires. He has an object in view and can see that object develop as his work progresses.

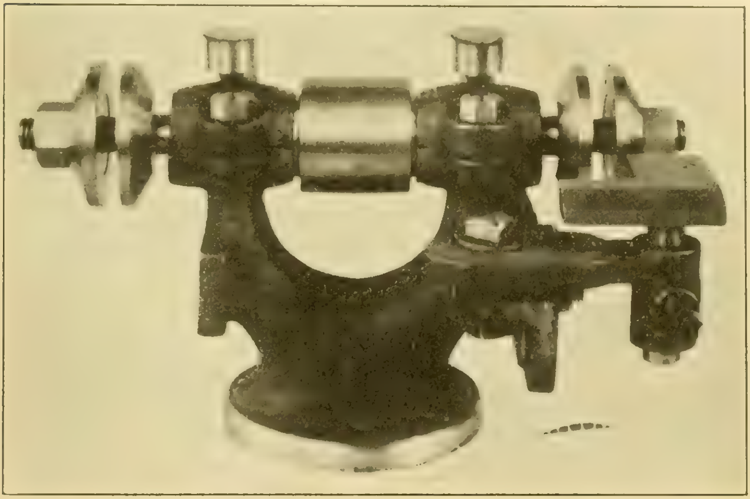
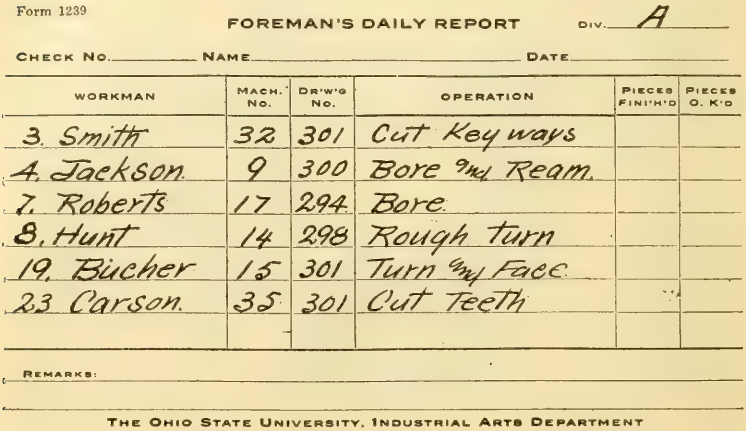


FIG. 1. Grinder of First Semester's Work.

The work of the class room parallels that of the shop. A more complete consideration can here be given of the various machines, tools, operations and methods than can be given in the shop. Having completed this semester's work, the student is more or less familiar with the machines in the shop, the small tools, tool room system, and has been introduced to many of the fundamental operations of machine work. He is then in position to take up the more advanced work.

SECOND SEMESTER'S WORK.

In this the class works as an organization. The work is run through in quantity and is interchangeable. Finished parts are inspected and pass into the stock room to be requisitioned out for assembly toward the end of the semester. An operation sheet is furnished the student, giving the tools, speeds and feeds and a standard time for each operation.



Form 1239

FOREMAN'S DAILY REPORT DIV. A

CHECK NO.______ NAME______ DATE______

WORKMAN	MACH. NO.	DR'W'G NO.	OPERATION	PIECES FINI'H'D	PIECES O. K'D
3. Smith	32	301	Cut Key ways		
4. Jackson	9	300	Bore and Ream.		
7. Roberts	17	294	Bore		
8. Hunt	14	298	Rough turn		
19. Bucher	15	301	Turn and Face		
23 Carson.	35	301	Cut Teeth		

REMARKS:

THE OHIO STATE UNIVERSITY, INDUSTRIAL ARTS DEPARTMENT

FIG. 2. Issued in this Form as Instructions to Foreman.

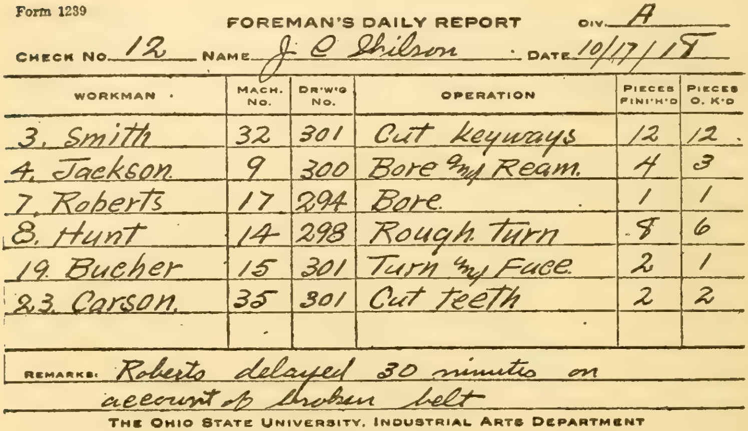
The organization is very simple. A class is divided into divisions of five to seven men each. These are lettered A, B, C, D, . . ., and each is in charge of a division foreman selected from members of the class. There is also an accountant who keeps the records. Ordinarily, the divisions are productive; that is to say, they work on the regular product of the shop, but practically with every class there is a maintenance division organized. The duties of this division are to make repairs for the upkeep of the equipment, make new tools, do development work and to take care of other little jobs that come along.

The foremen serve a period of four weeks. At the end of this period the standing of the class is determined, the foremen are retired to the position of workmen and their places filled by members of the class who have made the best grade for the four weeks' period. This is repeated at the end of another four weeks and so on until the end of the semester. A student, however, does not hold the position the second time, the selection being made from those who have not served in that capacity.

It is the duty of a division foreman to assign work, see that the proper speeds and feeds are used, give advice and assistance to his men, and, in general, perform the duties of a regular foreman. He should keep in close touch with the instructor, aiming to keep somewhat ahead of his men on the requirements of the work. The foremen also act as inspectors, each inspecting the work of his own division. When a piece is inspected it is marked with chalk, either O.K. (accepted) or N.G. (no good), together with the foreman's check number. A daily report is filed by the foreman showing the number of pieces finished and number O.K.'d by each of their workmen. (See Fig. 3.)

The accountant acts also as stock room keeper. The stock is placed in tote boxes ready to be handed out. The first duty of the accountant is to hand out these boxes. He then takes up the reports of the previous class and proceeds to enter them each in its appropriate place. He next adjusts the production board to correspond with the increase of production. Having finished this, he makes tests with schleroscope on two samples of hardened steel, recording his observations on blanks furnished for that purpose. There is then a set of ten defective castings to be inspected and reported on. This, together with taking in the boxes at the end of the period, finishes his work. The idea of the tests and inspection is to give the student something to do that will make his time in the stock room worth while. Members of the class serve in rotation as accountant, so that each man takes part in keeping the records which are at all times open to inspection. For this period as accountant the student is allowed *straight time.*

The managerial functions are performed entirely by the instructor, for the purpose is to teach shop practice rather than shop management. The instructor must do the planning, keep track of production, know before a class enters where every man is to be placed, the work he is to do and that the material is ready. His orders are, however, carried out by the division foremen.



Form 1239

FOREMAN'S DAILY REPORT DIV. A

CHECK NO. 12 NAME J C Wilson DATE 10/17/18

WORKMAN	MACH. No.	DR'W'G No.	OPERATION	PIECES FINI'H'D	PIECES O. K'D
3. Smith	32	301	Cut keyways	12	12
4. Jackson.	9	300	Bore & Ream.	4	3
7. Roberts	17	294	Bore.	1	1
8. Hunt	14	298	Rough Turn	8	6
19. Bucher	15	301	Turn & Face.	2	1
23. Carson.	35	301	Cut teeth	2	2

REMARKS: Roberts delayed 30 minutes on account of broken belt

THE OHIO STATE UNIVERSITY, INDUSTRIAL ARTS DEPARTMENT

FIG. 3. Comes Back in this Form as Foreman's Report.

OPERATING MECHANISM.

One of the most important items in this connection is the foremen's daily report form. This is used by the instructor in issuing orders to the foremen. As before mentioned the instructor "places" the class, that is, determines beforehand where and on what each member is to work. He writes in on the form the name, check number, machine number, drawing number and operation for each student. This is then attached to a 3 × 5 in. production order card which gives the number of pieces to be gotten out, and placed in a suitable rack accessible to the foremen. At the end of the work period a foreman has but to mark in the number of pieces finished and pieces O.K.'d, sign his name and turn the slip in as his report. This form, then, as shown in Figs. 2 and 3, goes out

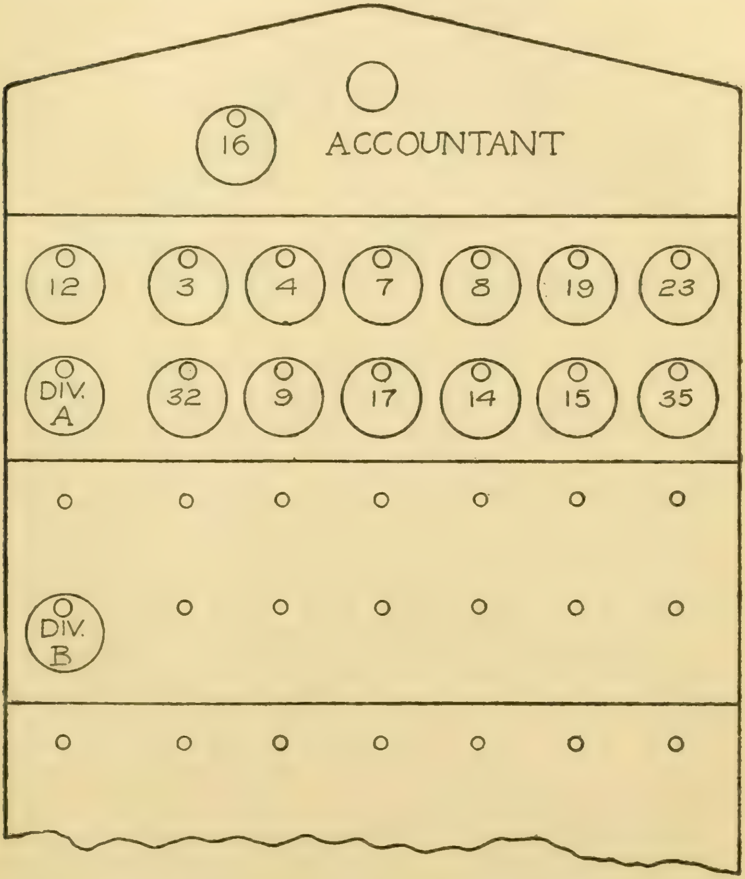
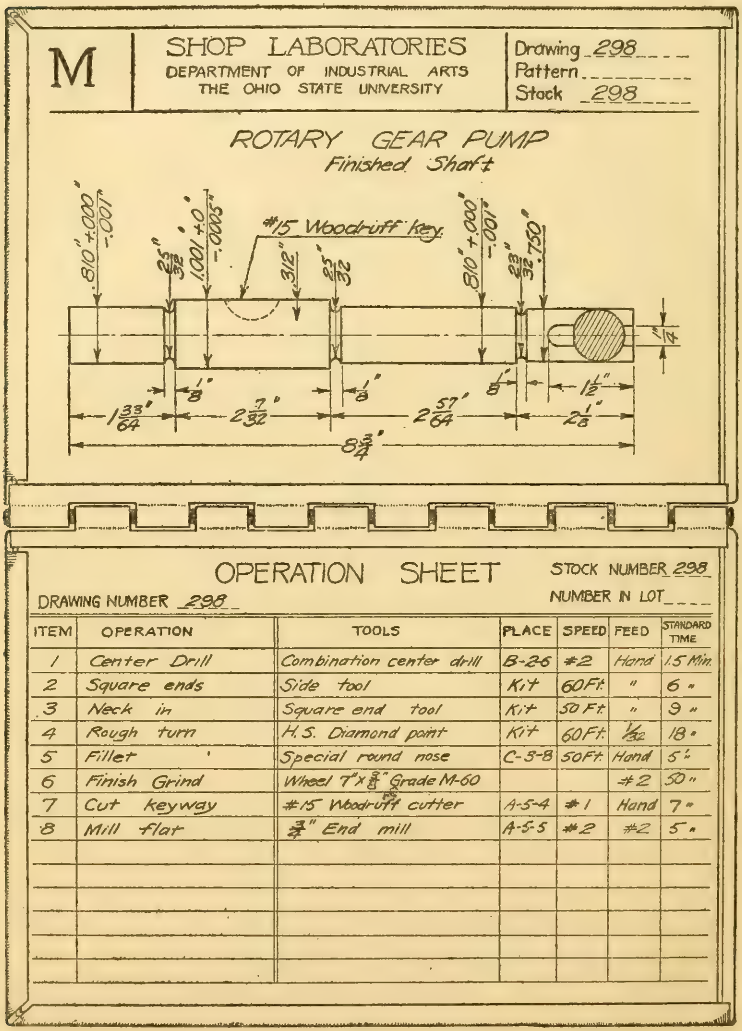


Fig. 4. Check Board.

as orders to the foremen and comes back as a report of the work.



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SHOP LABORATORIES
DEPARTMENT OF INDUSTRIAL ARTS
THE OHIO STATE UNIVERSITY

Drawing 298
Pattern
Stock 298

ROTARY GEAR PUMP
Finished Shaft

OPERATION SHEET

STOCK NUMBER 298
DRAWING NUMBER 298
NUMBER IN LOT

ITEM	OPERATION	TOOLS	PLACE	SPEED	FEED	STANDARD TIME
1	Center Drill	Combination center drill	B-26	#2	Hand	1.5 Min.
2	Square ends	Side tool	Kit	60Ft.	"	6 "
3	Neck in	Square end tool	Kit	50 Ft.	"	9 "
4	Rough turn	H. S. Diamond point	Kit	60Ft.	1/32	18 "
5	Fillet	Special round nose	C-3-8	50Ft.	Hand	5 "
6	Finish Grind	Wheel 7"×3/8" Grade M-60			#2	50 "
7	Cut keyway	#15 Woodruff cutter	A-5-4	#1	Hand	7 "
8	Mill flat	3/4" End mill	A-5-5	#2	#2	5 "

Fig 5. DRAWING AND OPERATION SHEET.

FIG. 5. Drawing and Operation Sheet.

The check board shown in Fig. 4 is also used in connection with the placing of a class. The board is divided horizontally into five spaces. Each space has room for two rows of checks and represents one division of the class. A vertical line separates the foremen from the workmen. Check numbers of the students are placed on the upper row while the lower carries the machine numbers. The student is to work on the machine, the number of which is immediately beneath his own check number. The first upper check to the left indicates the foreman of the division. As the board is now arranged in Fig. 4 the student whose check number is 12 is foreman of Division A. Numbers 3, 4, 7, 8, 19 and 23 are his men. Number 3 is to work on machine 32, number 4 on 9, and so on. To avoid confusion in handling, the checks representing students are of aluminum, while those representing machines are of brass. The arrangement of checks on the board must, of course, correspond with the orders issued to the foremen. There is also placed at the top of the board a single check to indicate which student shall act as accountant.

An operation sheet is issued with a drawing. This gives the sequence of operations, speeds, feeds, and a standard time for each operation. A sample drawing and operation sheet are shown in Fig. 5. These are inserted in a backing of galvanized iron, two pieces being hinged together like the covers of a book. The inside edges are turned over and so made that the drawing can be slipped in from the end. A piece of clear celluloid $1/64$ in. thick is inserted over the drawing, and also the operation sheet, to serve as a protection. This makes a flexible arrangement, as an operation sheet can be changed without disturbing the drawing, and yet they can be handled as one unit.

A production board such as shown in Fig. 6 is used. This shows the number of pieces finished, number spoiled and number available for the next operation. It is simply a rectangular board divided into squares into which different colored plugs may be inserted. Provision is made for suitable headings along the left side. Brown plugs are used to indicate good pieces, and yellow the spoiled pieces. When a report comes in, the yellow plugs are moved along to make room for good piece plugs and if there is any spoiled work it is tallied up by the insertion of additional yellow plugs.

While this board shows at a glance the state of production

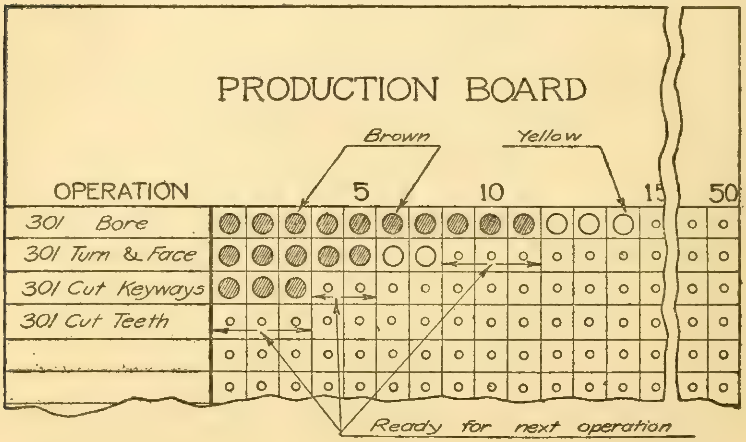


Fig. 6 PRODUCTION BOARD

FIG. 6. Production Board.

and jobs available for the next operation, it is not of much real service to the instructor in placing a class for the reason that it is always one work period behind the real shop condition. It does, however, serve a very useful purpose in bringing before the student the general character and use of such boards.

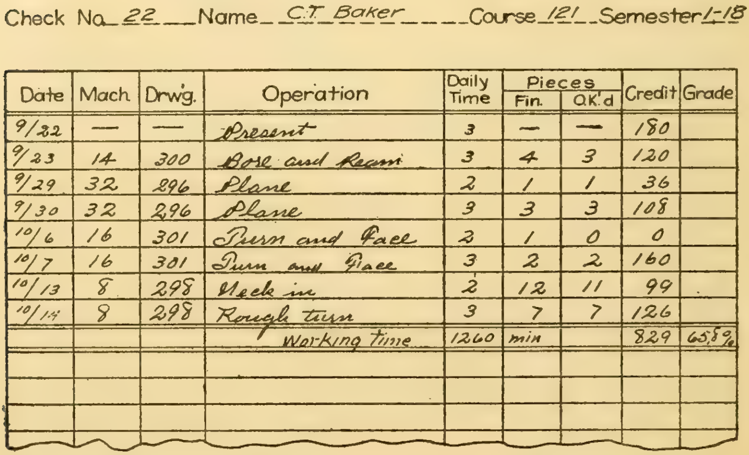
A more practical scheme for our purpose is the Finished Stock Rack. This is a section of steel shelving 12 ft. long by 6½ ft. high by 15 ins. wide, divided into compartments suitable for the work. There is a separate compartment for each operation. Take, for instance, finishing gears. The first operation is boring, (2) turning, (3) cutting keyway, (4) cutting teeth. All of the bored gears are placed in one compartment of the rack, those bored and turned in the next adjoining, and so on, beginning at one end of the rack and working toward the other. As soon as a class turns in its tote boxes the finished pieces are taken out and placed in the rack. A brief inspection then shows how many pieces are ready for the next operation.

OPERATION, GRADING, RECORDS.

On entering the shop no student knows where or on what he is to work. He first consults the check board which is placed adjacent to the tool room window. A glance at this tells him on which machine he is to work. He has his tool kit issued from the tool room and goes to his machine. Meanwhile, the foreman takes his orders from the rack, proceeds to his men and gives each his drawing number and operation. The student must then get his drawing and stock and is ready to go to work. It matters not whether the foremen know the men as they can be located by the machine numbers which are so placed as to be visible from either side of the shop. Some foremen adopted the plan of getting in a little ahead of the class, writing each man's drawing number and operation on a slip of paper and leaving it at the machine. In this way the student had the desired information as soon as his machine was reached. Not a bad scheme.

A student performs a single operation for an allotted period of time. This is usually a 2-, 3- or 5-hour period. If the operation is, say, grinding shafts, which is a 50-minute job, the period would be 5 hours and the student would finish as many shafts as he could in that time. On a short time operation, like squaring ends, for which the standard time is 6 minutes, the period would be 2 hours or even less. Since we have a 2-hour work period one day (1 hour out for lecture) and 3 the next, these are the natural intervals between shifting from one operation to another. Production could be increased and spoiled work diminished by increasing the time between shifts. However, it is desired to give the student as many different operations as possible and not have him repeat until the work becomes monotonous. A maximum of 5 hours has been found to be sufficient for the more difficult operations, while 2 to 3 hours serve the purpose well for the more simple.

The student's shop grade is based entirely on his efficiency, this being the ratio of the time it takes him to complete an operation to the standard time for that operation. He gets no credit for spoiled work. No allowance is made for getting in, getting out, set up or time that a class may be called up for instruction. All of this has been taken into account in setting standard time. Consider again the grinding of shafts —a 50-minute operation. In the 5-hour period a student should finish 6 shafts and have them pass inspection in order to make a grade of 100 per cent. If he finished but 3 or finished 5 and 2 were rejected, his grade would be 50. However, the grades are not figured for each 2- to 5-hour period,



Check No. 22 Name C.T. Baker Course 121 Semester 1-18

Date	Mach.	Drwg.	Operation	Daily Time	Pieces		Credit	Grade
					Fin.	O.K.'d		
9/22	—	—	Present	3	—	—	180	
9/23	14	300	Bore and Ream	3	4	3	120	
9/29	32	296	Plane	2	1	1	36	
9/30	32	296	Plane	3	3	3	108	
10/6	16	301	Turn and Face	2	1	0	0	
10/7	16	301	Turn and Face	3	2	2	160	
10/13	8	298	Neck in	2	12	11	99	
10/14	8	298	Rough turn	3	7	7	126	
			Working time	1260	min		829	65.8%

Fig.7 STUDENT'S RECORD SHEET. SIZE 8½ x 11.

FIG. 7. Student's Record Sheet. Size 8½ × 11 inches

but for a period of 4 weeks, which greatly simplifies the clerical work and keeping of records.

A complete record of the student's work is kept on the form shown in Fig. 7. The first entry shows that C. T. Baker was present the first day. This period is given over to an explanation of the system and a couple of demonstrations. If present, the student is allowed full time of 180 minutes and this is entered in the credit column. The next day he was on machine 14, drawing 300, operation boring, and the record shows that he finished 4 and had 3 accepted. The standard

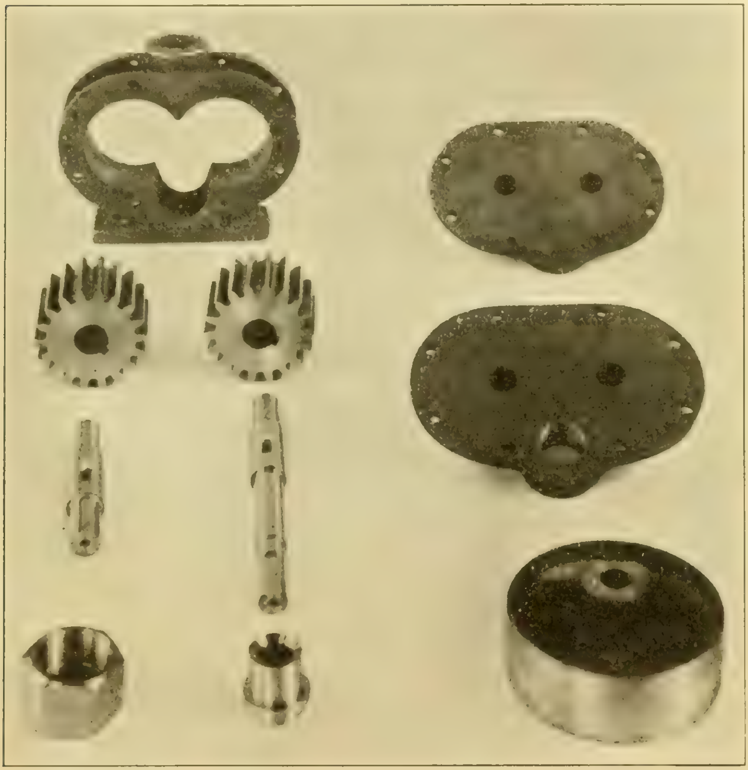


FIG. 8. Parts of Gear Pumps.

time for this operation is 40 minutes, hence 3 times 40, or 120, is carried over into the credit column. At the end of 4 weeks this column is added up and divided by 1,200, the number of minutes he should have worked, and his grade thus obtained. It makes no difference whether a student works full time or not, the divisor is the same for every member of the class. Thus the effect of lost time through getting in late or absences and spoiled work is automatically to lower the student's grade.

The principal work of the semester is the making of a number of small gear pumps, the parts of which are shown in Fig. 8. This furnishes a reasonable variety of work, all of which must be fairly accurate. There are no very large nor very small parts and few special tools are required. A sufficient number are run through to provide one for each member of the class. Then, toward the end of the semester, a complete set of parts is issued to each student who assembles and tests his own pump. In addition to the required number of pumps, the work of the semester includes standard tension test bars, brass ink wells, screw jacks, hex nuts and cap screws made on a turret lathe. With a class of 40 there would be about 60 test bars, 40 ink wells, 12 to 15 screw jacks, 100 hex nuts (sides milled) and 200 to 300 cap screws run through. Some work of this kind is necessary, for as operation on pump parts are completed there must be something on which to keep the class at work. These are shown in Fig. 9.

Much thought was given to the selection of a proper exercise. The gas engine made a strong appeal, but it could hardly be seen that one complete engine could be finished for each member of the class in the time allotted, not unless jig and special tool work was carried to an extreme. It was preferred to have a large number of machines with few parts rather than a few machines with a large number of parts. Due consideration was also given to providing the foundry with a suitable class of work. No doubt, however, there are numerous other machines that would serve the purpose well.

In setting standard time no previous records of the time of students were made use of. The cutting time was in every case calculated for such cuts and feeds as the work or our equipment warranted and then allowances were made for getting started, handling, measuring and time out for instruction. Working individually, the average time of a 1$\frac{5}{8}$ in. screw jack was 28 hours. Run through in lots of 12 to 15 the standard time is now 8 hr. 20 min. The time on the ink well was 8 hr. It is now 1 hr. 50 min.

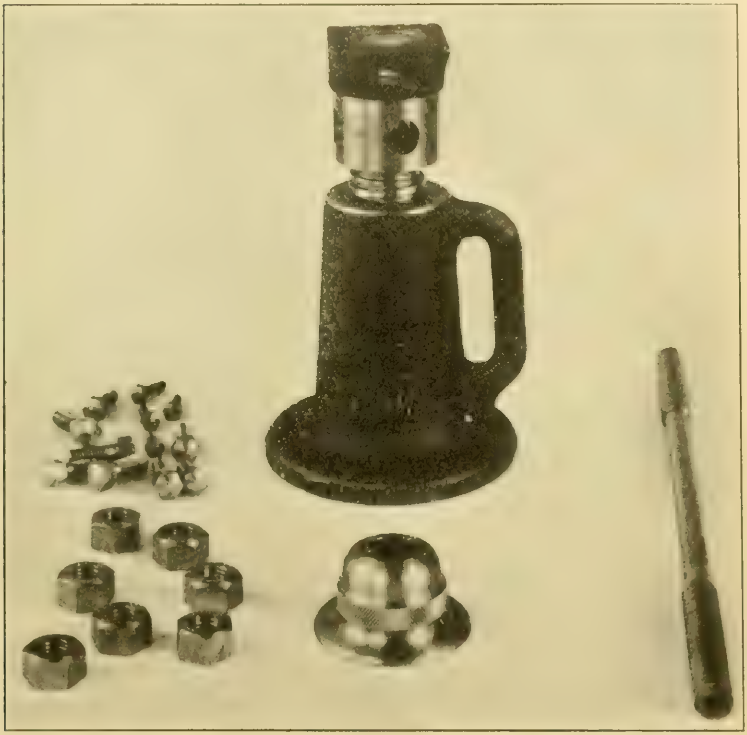


FIG. 9. Other Products made in Quantity.

This system is workable—it has the elements of modern shop practice, *i. e.*, organization, interchangeable parts, work limits, inspection, standard time and progress reports. The student is brought into contact with these features in addition to his regular practice in the handling of machine tools. He must run his machine at the given speeds and feeds and receive proper instruction or he can not make anywhere near standard time. There is no puttering along taking two or three cuts where one will do. The cutting tools must be of correct form and the equipment must be kept in good condition. This method does not provide as many different operations for the student as when he works individually, but he obtains a more thorough knowledge of the ones he does get. The length of time on one operation is not such as to lead to monotony, but is sufficient for the student to gain confidence in himself and begin to learn what the output of a tool should be. The student is "on the job" every minute of the time.

On the other hand, there is less opportunity for the student to exercise his individual judgment. There is much additional work required of the instructors both in the way of preparation and attention while the class is in. No instruction sheets other than the operation sheet are furnished. The student has no time to stop and analyze instruction sheets. He must be shown or instructed in the proper way to do the job.

Records show that for the second 4-weeks period there is an average gain of 15 per cent. in the standing of a class. The gain is 9 per cent. during the third period, and no gain or perhaps a slight loss during the last 4 weeks. The latter is explained by the fact that limits of production are about reached, the work is "tailing out," odds and ends are being cleaned up and the work can not be carried as advantageously as earlier. Since the operations performed by the student are not repeated, the gain can be said to fairly represent an increased ability to perform work.

PRELIMINARY REPORT OF COMMITTEE NO. 12, ENGLISH.

C. W. Park, *Chairman,* University of Cincinnati; Frank Aydelotte, Massachusetts Institute of Technology; J. R. Nelson, University of Michigan; S. A. Harbarger, New York City.

The gradual return of normal academic conditions, following the S. A. T. C. period, is encouraging to the committee, since much work can now be resumed which had to be set aside last year. From communications that have been received since the re-opening of the colleges, it is evident that the temporary suspension of the usual courses has been in some respects beneficial. Instructors show a disposition to revise their subject matter and methods, and they bring to the revision a variety of experience and a fresh point of view, gained in some form of war service. The new start in all lines of instruction makes the time a propitious one for a re-examination and, where desirable, a reconstruction of the curriculum.

Fortunately, just when conditions are most favorable for the introduction of changes in materials and methods, the report of Dr. C. R. Mann on "Engineering Education" is available as a guide in reconstruction. The publication of this work at any time would challenge a testing of every instructor's work by the standards of engineering training which it sets forth. Its appearance at this time is highly significant.

Among the passages in Dr. Mann's report which bear upon the question of English instruction, the following are regarded by the Committee as being especially suggestive.

"With regard to instruction in English, the engineering schools may be divided into two approximately equal groups, the one composed of those schools that maintain the current standard college course; and the other composed of those that are trying to discover a type of work better suited to engineers. In the standard type of course, the student studies a text-book of composition and rhetoric, learns the rules of correct punctuation and paragraphing, together with the four forms of discourse, and then writes themes on assigned subjects selected by the instructor to give practice in either description, narration, exposition, or argumentation. In some schools the strict adherence to this plan is mitigated by allowing a choice from among several assigned subjects. The accompanying study of literature consists of a brief survey of the lives of the great writers and the analysis of selected passages from their writings. This well-known type of course was developed during the latter half of the past century for the purpose of making English an acceptable substitute for the classics in high schools and colleges.

''Doubtless because the professional engineers have been so frank in their demand for better training in English, about half of the engineering schools are experimenting with their methods of teaching this subject. These experiments are so varied in plan and execution that it is not possible to classify them.'' (Chapter VII, page 42.)

''Therefore congestion of the curriculum is inevitable so long as each department remains sole arbiter of the content of its courses, and there is no coördination among departments with respect to the amount and the nature of the subject-matter in courses, and no scrutiny of the results of each department's work by some agency outside the department.'' (Chapter IX, page 56.)

''At this shool (Massachusetts Institute of Technology) English is a required subject for all students throughout the first two years. The first half of the freshman year is devoted to general composition, with the object of eliminating the more common errors of construction and of leading the student to see that excellence in writing comes not so much from the negative virtue of avoiding errors as from the positive virtue of having something to say.

''The work of the second term of the freshman year begins with a class discussion of such questions as: What is the difference between a trade and a profession? What is the meaning of the professional spirit? What should be the position of the engineer in society in this new era of the manufacture of power—that of hired expert or that of leader and adviser? Is the function of the engineer to direct only the material forces of nature, or also human forces?

"Having discussed the question: What is engineering? the class proceeds in the same manner to wrestle with such problems as: What is the aim of engineering education? What is the relation between power of memory and power of thought? Is there any connection between a liberal point of view and capacity for leadership? What qualities do practical engineers value most highly in technical graduates? What is the relation between pure science and applied? What is the relation of science to literature? The authors read in connection with the discussion gradually change from engineers to scientists like Huxley and Tyndall, and then to literary men like Arnold, Newman, Carlyle, and Ruskin. The student seems to read this material with no less keen interest than was shown for the writings of engineers; so that through his own written and oral discussion of masterly essays each comes to work out for himself some rational connection between engineering, with which he began, and literature, with which he ends. No orthodox point of view is prescribed; his own reason is the final authority. The aim is to raise questions which it may take half a lifetime to answer, but the thoughtful consideration of which will give a saner outlook on life and on his profession." (Chapter X, pages 63–64.)

"Thus there is a widespread agreement among professional engineers that the college curriculum should aim to give a broad and sound training in engineering science, rather than a highly specialized training in some one narrow line; that considerable attention should be paid to humanistic studies like English, economics, sociology, and history, not merely because of their practical value to the engineer, but also because of their broad human values; and that the young graduate should have some conception of business management and of the most intelligent methods of organizing and controlling men.'' (Chapter XIII, page 88.)

''The humanistic studies make up the fourth type of work essential to the training of every engineer. The professional criticisms of the schools indicate that this field offers the greatest opportunity for effective changes in current practice, because lack of good English, of business sense, and of understanding of men are most frequently mentioned by practising engineers as points of weakness in the graduates of the schools. The criticisms point out two types of weakness, namely, lack of technical facility in expression, in business, and in handling men; and lack of appreciation of and interest in literature, economics, and social philosophy. Clearly the humanistic departments are not alone responsible for these weaknesses, for no amount of drill in the technique of language will make a student write and speak clearly if he does not think clearly; and training in clear thinking is as much the function of the teachers of science, mathematics, and engineering as it is the function of the teachers of English. And if the professors in the technical subjects rigidly exclude from their instruction all discussion of human values and costs, is it reasonable to expect the students to appreciate economics and social science? As every one is aware, languages, economics, and social sciences are generally treated as 'extras' in curricula, and are as generally regarded as superfluous 'chores' by the students.

''The difficulty in present school practice evidently lies in the exclusion from the technical work of all consideration of the questions of human values and costs; and, conversely, the isolation of the humanistic studies from all technical interest. The theory has been that engineering at best is tied to materials; but that it can be made less materialistic by ignoring the question of dollars and cents in the technical work, and by teaching science, mathematics, economics, and literature for their own sakes entirely isolated from inherent technical relationships. This conception, however, is gradually giving way, for the experiments described in the last four chapters indicate that technical work is more impelling, and is, therefore, more fully mastered, when it includes the consideration of values and costs; while humanistic work becomes significant, and therefore educative, when it starts from and builds upon the professional interest. And after all, the ultimate control of all engineering projects, as of all activities, is vested in some man's decision that the game is really worth while; and this control is likely to be more salutary, the more completely the man who decides comprehends the full import of the values and costs involved.'' (Chapter XIII, pages 92–93.)

''Because the appraisement of values and costs is the controlling factor in engineering, the final important change from current school practice that is suggested deals with the humanistic studies. The usual method of treating these subjects in short independent courses in the technique of composition, literature, history, economics, and so on, seems less likely than the method proposed (page 92) to develop the desired insight into these profound problems of value and cost. The experiments at Wisconsin and the Massachusetts Institute have progressed far enough to show how successful this type of work is with freshmen in developing powers of both forceful expression and appreciation of good literature. Therefore it seems reasonable to expect that the extension of this work into a consecutive course extending through the entire curriculum and consisting of live discussions and extensive study of the best that has been thought and said concerning the immediate and the ultimate values in life, offers the most promising solution of the problem of culture for engineers.'' (Chapter XIII, page 99.)

''The statement that individuality counts for as much as learning for the engineer, just as it does for the lawyer or the physician, seems like a veritable platitude. Yet because the engineering schools have always made it their chief aim to impart the technical information needed in industrial production, and because both scientific knowledge and industrial practice have grown so rapidly, the attention of technical schools has been focused chiefly on keeping up to date in science and practice. The university emphasis on research in natural science has also tended to magnify the importance of technique and to minimize the importance of personality; until curricula have become so congested with specialized courses that students generally regard literature and sociology as unnecessary chores, to be endured rather than enjoyed. Therefore it seemed necessary to consider the question whether this emphasis on technique is producing a new and higher type of engineer, or whether the engineering profession still stakes its faith on the fundamental thesis that personal character is, after all, the real foundation for achievement.'' (Chapter XVI, page 106.)

''The organization of curricula proposed in Chapters XIII and XIV is suggested as one practical method of harmonizing the conflicting demands of technical skill and liberal education. It coördinates the results of numerous individual experiments in a consistent program. It recognizes all the essential elements and factors of engineering as well as the educational requirements of motivation and interrelation. It is not a utopian dream, but a summation of the best that has been thought, said, and done in education during the past two centuries. Finally, it embodies the modern conception of the professional engineer, not as a conglomerate of classical scholarship and mechanical skill, but as the creator of machines and the interpreter of their human significance, qualified to increase the material rewards of human labor and to organize industry for the more intelligent development of men.'' (Chapter XVI, page 113.)

In the brief synopsis which follows, the present scope of the committee's activity is indicated. Broadly, its aims are twofold: first, to stimulate discussion of current problems in English instruction for engineering students; and second, to act as a clearing-house for practical suggestions which may be useful to teachers of English in engineering colleges. The first of these objects contemplates a discussion which would interest not only teachers of English but also instructors, administrators, and others who deal with English chiefly as a part of the general scheme of engineering education. The second object has to do with discussions of immediate practical or classroom value, including such exercises, outlines, and other "tricks of the trade" as may be used by instructors and students. Instead of requesting answers to a questionnaire, the committee invites instructors and others interested to send contributions of both kinds to the chairman. The general discussions may be based on the quotations from Dr. Mann's report, the topics suggested in the committee's 1918 and 1919 reports, or on any other subject of interest. The more brief and concrete the contributions, the more useful they will be. Sections of this year's report will deal with such subjects as "The Humanities in the Engineering Curriculum," "The Development and Expression of Individuality," "The Growing Emphasis on Oral English" and "Specialized Training in English for Engineers."

As an example of the kind of material which may be included under "practical suggestions," the following typical outline for a laboratory report is offered. This outline, it may be noted, was worked out by laboratory instructors in physics, electrical engineering and mechanical engineering on the one hand, and by a department of English on the other. The committee feels that on the more formal side of technical writing many such plans exist, which even if not adopted entire, would at least be interesting for comparison. In those even more important phases of instruction which cannot be classified, a concrete description of an instructor's method of approach may be widely useful if shared with his fellow instructors.

TYPICAL OUTLINE FOR A LABORATORY REPORT.

Although laboratory reports differ widely in subject matter, the problem of organization is very similar in all of them. The outline given below represents a logical development of the subject as well as a convenient distribution of the material in the report of a test. With a few changes here and there to fit special conditions, this form will be found serviceable in the writing of nearly every kind of laboratory report.

1. *Object.*—This division should consist of a clear, full, and concise statement of the object, preferably in the form of a simple declarative sentence. Since the report is not written until after the test has been performed, the statement should be put in the past tense; *e. g.*,

"The object of this test was to determine the steam consumption of a Brownell 10 × 12 engine."

2. *Theory.*—This division should contain a general statement of the data to be obtained in such a test, together with the fundamental principles on which the test depends. For example, the second paragraph of the report indicated above might begin as follows:

"In testing for steam consumption, the chief data to be obtained are (*a*) the horsepower of the engine, and (*b*) the weight of the steam passing through the cylinder in a given time."

Where formulas are to be applied in the test, they should be given in this part of the report.

Since the discussion deals with general theory, this section of the report should be expressed in the present tense.

3. *Apparatus.*—The apparatus used should be described, with emphasis on new apparatus and on special devices used in the particular test in question. At the beginning of the section, the various pieces of apparatus should be enumerated. New and special pieces may then be described in detail.

In so far as this part of the report deals with particular apparatus, it should be put in the past tense; *e. g.*,

"The apparatus used in this test consisted of the following," etc.

4. *Procedure.*—This section contains an account of what was done in carrying out the successive parts of the test. Care should be taken to omit preliminary and non-essential operations, and to follow the actual order in which the work was done.

The narrative should be impersonal, and should be given in the past tense and the passive voice; *e. g.*,

"Readings *were taken* at intervals of five minutes," etc.

5. *Results.*—(*a*) Summary of results: Conclusions drawn from the data should be stated briefly and clearly. In some cases it may be desirable to compare them with results obtained in other tests. (*b*) Curves. (*c*) Sample calculations: These may be brief, but they should be typical of the mathematical processes involved. (*d*) Data: The data should be presented on special paper designed for the purpose, and should be arranged in tabular form and in parallel columns.

6. *Sketches.*

7. *Original Data.*—Rough notes taken during the test should be submitted from time to time as evidence of the accuracy with which observations were made. If a log book is kept, it will answer the purpose.

Respectfully submitted,

C. W. Park, *Chairman.*

TECHNICAL ENGLISH: A DIAGNOSIS AND A PRESCRIPTION.

BY A. STARBUCK,

Instructor in English, Iowa State College.

The Committee on English of the Society for the Promotion of Engineering Education in the report for 1917 calls attention to the unsatisfactory preparation in English of recent graduates of engineering schools. A letter addressed by Professor J. M. Telleen to twenty-five prominent engineering companies, asking, among other things, for a statement concerning the English preparation of recent engineering-school graduates, brought replies from fifteen. The substance of these replies, so far as they relate to English preparation, is contained in a brief paragraph on page 220, PROCEEDINGS of the Society for the Promotion of Engineering Education, Vol. XXVI, 1917:

"To the question, Is the recent engineering-school graduate equipped with a knowledge of English sufficient for the work he is called upon to do?, two answered in the affirmative, eight answered with a positive No, and the others expressed themselves as being dissatisfied with the ability of the average graduate to use the English language."

Such a report is disturbing; if we had not for some time suspected the facts it lays bare it would be startling. It points, apparently, to some deep-seated trouble; and those interested in the teaching of English will be concerned with the situation and willing to spend some effort in an attempt to remedy it. But in mental no less than in physical ailments any attempt to apply a remedy ought to be preceded by a diagnosis. When once the seat of the difficulty is located, the means of improvement may follow as a logical consequence. It may then be worth our while to inquire whether our poor results have come from a failure to understand what we should teach, from faulty methods of presentation, from a wrong student attitude toward the subject, or from something which is neither one nor the other of these things, but which is closely connected with the last two and in large part determines both of them. After these factors have been examined it will be time enough to put the question, "What shall we do about it?"

And what, in the first place, shall we say of the things we teach? Here at least there will not be much difference of opinion, and we need not therefore tarry long. The writer or the speaker must in the beginning understand how much of his subject the reader or the audience wishes to know, and must organize all the material he presents so that the main points will stand out with perfect definiteness. He must construct his paragraphs in such a fashion that they will in orderly sequence present the various topics which compose the different main divisions. He must write sentences whose structure reflects the thought they are intended to convey. And he must choose words which actually name the ideas he wishes to put into the mind of the reader or the hearer. These are the main things, the things on which all further study must be based. They commend themselves to the judgment of all thinking persons; and in one order or another all teachers of English composition cover them.

If we are substantially agreed as to what we shall teach, are we as fortunate in regard to the manner of teaching it? We must admit that on this point we shall find no such unanimity of opinion. We have had methods and methods; and when these have failed we have had other methods. Every new text has its method, and every teacher uses his own method, whatever the text he uses, and whether or not he uses any text at all. And then when we learn from the men out in the field that our technical graduates do not have a language equipment sufficient for the demands of their profession, we examine our methods and look about us for a text with a new and more appealing method. Our methods, we shall have to admit, have been as varied as our personalities.

Shall we then conclude our search at this point and say with some of the critics that the unsatisfactory English preparation of technical students is due to poor methods of instruction? Undoubtedly our methods are not yet perfect. But before we fix on the mere methods of English class-room instruction the responsibility for our failure, let us ask whether the methods of English instruction are fundamentally very different from the methods of instruction in other subjects. An English teacher may perhaps be pardoned if he professes no very extensive knowledge of methods used in the presentation of subjects other than his own. Most of us have, however, sat through from four to seven years of college instruction in various subjects; and we have probably not discovered from this experience much closer agreement as to class-room method among other teachers than among teachers of English. In the teaching of other subjects, no less than in the teaching of English, personality determines method; and unless we are to believe that English teachers as a class are deficient in personality, the difference in results obtained must be sought, very likely, elsewhere than in difference of method.

Where, then, shall we turn? It will do no harm to inquire into the attitude of the technical student toward a study of language. And here for the first time light begins to break in upon our problem. The average teacher of English will tell you that the average technical undergraduate is not enthusiastic over his English.

"We should rather have our time for our practical subjects; we want something which we can turn to practical account when we get out of school." This is what he will tell you when you get close enough to him to find out what he is really thinking. And in this confession of faith we come pretty close to the location of the language problem. In spite of the favorable attitude of technical men both in and out of college the average technical undergraduate, because he thinks the study of English impractical, finds it far from attractive.

How prevalent this lack of interest really is may be illustrated by a recent experience of an English teacher. A sophomore engineer in one of his classes had done rather better than average work. The teacher was, therefore, surprised and somewhat taken aback when the student came into his office soon after the close of the semester.

"Didn't you find your report satisfactory?" the teacher asked, reaching for the student's papers in the hope of confronting him with a misspelled word or a dangling participle.

"I don't mean that," he said, observing the teacher's distressed look. "But you wrote on one of my papers that I could improve my style by studying the works of good writers. I thought you might tell me where I could find something good." The teacher looked at the young man a moment, and then, getting his point, handed him a book. As soon as the student left, the teacher hurried in with the news to the chairman of the engineering group of English teachers. The latter was as much impressed with the novelty of the occurrence as the teacher had been.

"Remarkable," he declared; "take a note of that; it's worth remembering." This young man he found so unusual as to merit more than passing notice, for he, too, understood that the average technical student is not fond of English.

To be sure, there are exceptions to this generalization. A good many technical students do value training in English at something near its real worth, and give it serious attention. Some instructors, too, with rare skill succeed in gaining the interest of their classes and in adding to the number of those who value such training. But with grateful acknowledgment that both this kind of student and this kind of English instructor exist, we accept neither as typical and return to our generalization as a safe working hypothesis.

But all this is no news. Both English teachers and teachers of technical subjects have for a good many years recognized that technical students do not love English, and have tried to remove their distaste for the subject. Most of our search for an improved method has been inspired by our eagerness to present our subject in an attractive manner, because, feeling sure of what we should teach, we have been certain that in so far as we failed our failure was due to a lack of appreciation on the part of those we tried to teach.

A few years ago we thought the way out lay in the direction of segregation. If students of engineering could be grouped in classes by themselves and permitted to write on engineering subjects, or better still, if civil engineers could be grouped in one section, electrical engineers in another, mechanical engineers in a third, and so on through the range of the engineering departments, they would find the subject more attractive, and their composition would improve. But in some of our technical institutions more than one college generation has grown up under segregation, and although the plan is very likely a step in the right direction, it is still not evident that the solution of the language problem has been found. Under segregation the attitude of technical students, always with exceptions, of course, has remained substantially what it was before, because they still question the usefulness of the training required of them. Segregation has not removed the technical student's objection to language training, because the lack of segregation was not in the first place responsible for that objection.

Now what has happened in the case of segregation will probably happen in the case of other proposed remedies unless our diagnosis goes further than it has yet gone. It is not enough to say that the unsatisfactory English equipment of technical graduates is due to a lack of interest in the subject while they are undergraduates. It is not even enough to explain their lack of interest by saying that they do not class English composition as one of their practical subjects. We can not proceed with any confidence until we have inquired why they do not so class it.

And when we come to this inquiry we must not advance too rapidly, for the trail is not too well traveled. But there are at any rate certain marks which may keep us from losing our bearings. We can not, in the first place, throw the blame upon technical men engaged in the practice of their profession. In address after address, and in article following article, they have given testimony to the importance of adequate expression. Indeed, it is chiefly on account of their dissatisfaction that we are now so much concerned over the matter. Nor can we, in the second place, accuse technical men within college walls of any unfavorable attitude toward the study of English composition. Almost without exception the heads of technical departments have been generous in according time to the subject, and English teachers pay tribute to the willingness with which technical faculties have met their advances. The attitude of technical men, both in the professions and in the colleges, has been most favorable to the teaching of English.

It may, then, seem strange that undergraduates in technical schools do not share this favorable attitude. But let us not too hastily condemn even them. They are for the most part earnest, hard-working students; and they are the raw material from which technical men, in and out of college, are to be made. When they have left college behind them they will themselves writes articles and deliver addresses in favor of English training. This being the case, if we find them nevertheless through succeeding generations of college life consistently discounting the study of English composition, we ought to seek the explanation for this apparent inconsistency within the college. Since, however, we have in one way or another managed to exonerate all parties of blame as to method or attitude, we must look for the seat of the trouble, apparently, to something deeper than method or even attitude.

Now, the only thing which seems to go deeper than either method or attitude is a failure to make the technical student see that English composition is a study fundamentally different from any other study in the curriculum. The sanitary engineer studies bacteriology because it lies at the roots of his profession; the electrical engineer, if he studies bacteriology at all, does so, probably, not because he expects to make any professional use of the subject, but because he wishes to know something of science outside his own profession and happens to have been attracted by bacteriology. If his taste had been different he would have elected botany instead, or perhaps zoölogy, or psychology. And so it is, with a single exception, throughout the entire field of human knowledge. Any subject which finds its way into a course of study leading to any given profession is chosen always for one or the other of two reasons: either it contributes a store of ideas necessary to the pursuit of that profession, or it helps to broaden the outlook of the professional man by supplying him with ideas outside his profession. English literature, along with bacteriology, botany, and the rest, belongs in the latter class of studies. The teacher of literature or the literary critic must study literature, because it furnishes him his stock in trade. But the engineer, if he studies literature at all, does so because he thinks it has cultural value, because, as one prominent engineer in his lifetime would have put it, literature increases his ''competency to appreciate and enjoy.'' Thus we find it everywhere: all subjects, save only one, are capable of this double classification: for some professions they are essential, for others merely desirable.

And this one exception, of course, is English composition. Since it is the medium for the communication of thought in all fields of activity, it follows that its relation to every other subject is precisely the same. Language in one form or another, good, bad, or indifferent, we must all use whenever we have a thought to express.

We can not, however, get past this point without an objection. We have long recognized the importance of English training, some one says, and have required it in practically every course of study, technical as well as cultural. Almost no school now grants a degree in liberal arts, in pure or applied science, without more or less work in English. It is a sufficient answer to this objection to say that our failure to make the student understand the subject of English composition does not lie in any failure to make him pursue the subject. Every school, to be sure, has its department of English; some schools have a dozen or more separately numbered courses in English composition. In some one or more of these courses practically every student is required to register. He is required to write a certain specified number of papers, of a certain specified length, on certain specified topics, frequently not much to his liking; and along with these papers he does more or less oral work. During this time there is held before him a standard of expression rather high, sometimes so high that he does not see its logic. If he falls below this standard his paper is returned to him and he is required to make corrections in red ink or to rewrite the assignment. We have made the student understand pretty thoroughly that he must study English.

Have we made him understand as well that he must actually use his knowledge of English anywhere except in connection with his formal study of the subject? The answer is not far to seek. While his formal English work is going on the technical student is doing other writing and other speaking of a different sort. In connection with laboratory experiments, inspection trips, and other kinds of practical work he is frequently called upon for reports; and in connection with seminars he sometimes has to present topics orally. And, finally, before graduation, he has to present a thesis, a composition of greater volume than he is likely to be called upon by his English teacher to produce at any time during his college career. Altogether the technical student in a great many cases, does, perhaps, more writing and speaking outside his English courses than within them.

All this outside work has had from the beginning rigid supervision from the standpoint of its technical content. But until recently the English teacher has not been required to pass upon its form. In all probability it has been a source of satisfaction to some students to imagine that the English teacher has not been permitted to pass upon its form. We have required technical students to classify in certain courses of English composition, and have trusted that they would make use of the principles there studied in whatever written or oral work their other courses required them to do. But with very few exceptions we have made no attempt to check this written or oral work to see that they actually do make use of these principles. We have not yet generally so organized our English instruction that the teacher of English knows very much of what his students write or talk about other than in the pursuit of their formal study of English. Indeed, in some schools even to-day it would be considered improper for a student to present as an English exercise any written work for which he had received credit in some other subject. And so he goes through college, writing for his English courses papers in which the manner of expression is considered more seriously, perhaps, than the subject matter, and for his technical courses papers in which the manner of expression is at least not emphasized, in which it is at times almost ignored.

If the situation here presented with reference to the organization of our English instruction has not been overdrawn, what is its bearing on the English problem? What is the technical undergraduate likely to think of all this praise of English training from technical men outside the college, of all this piling up of English courses by the heads of technical departments within the colleges? The old proverb supplies the answer: Example is better than precept. The undergraduate will not look very far beyond the face of the returns. He will not easily see the necessity for a standard of expression higher than that which is required of him in his technical courses. As long as there is a difference between the standard of expression in his English courses and in his technical courses he will choose as his standard that which is set up in his technical courses, not because it is lower, but because he assumes it to be the standard of his technical instructor.

This, then, in brief is our diagnosis: our technical graduates write poorly because as undergraduates they consider English composition a subject of no great practical importance. They take this attitude because of the double standard of expression fostered by the present organization of our English training. This organization has grown up because we have not generally in the past ourselves understood the fundamental difference between the nature of English composition and the nature of any other subject in the curriculum. That is to say, we have in our teaching segregated a subject which by reason of its peculiar constitution can flourish only when widely distributed throughout the remaining subjects in the curriculum.

If this diagnosis is accepted as sound it will not take long to write the prescription. Since the relation of English composition to all technical subjects is the same it would seem logical to standardize the requirements in composition in all technical courses of study. A minimum course in English for all technical schools should give to formal class-room study just so much time as will suffice to present with perfect clearness those principles which are actually usable in writing and speaking. The student should do less writing than he now does in most cases on assignments made by the English instructor; but every paper he writes in the study of any subject, technical or cultural, during his entire course of study should pass not only under the eye of the instructor making the assignment, who would judge its content, but also under the eye of the English instructor, who would judge its form. To this minimum course there should be added other special work elective for those students who show aptitude for expression and are likely to become writers or speakers.

The plan here suggested in barest outline is not proposed as a panacea. We have tried so many disappointing remedies that a modest person ought to have some suspicion that he may be himself a quack. But the plan has at least the merit of consistency: it compels the technical student in the preparation of those papers which he is most likely to consider practical to use the principles of writing which in the English class-room he has studied and seen illustrated; and it ought to make impossible in the mind of the student any notion that his technical instructor, in spite of a theoretical approval of good English, is after all not deeply concerned over the student's poor English.

Before the plan is pronounced radical let it be remembered that already a good deal has been done which points toward some such step. In the report of the Committee on English referred to in the beginning of this article, page 222, among the recommendations for the improvement of English offered by the managers of engineering companies, we find this language: "The written work required by the engineering departments should be submitted to the department of English for criticism; the students should be graded for the English they use in the recitations of all departments; the same weight should be given to correctness in the English of experimental reports that is given to exactness in mathematical calculations." Recently, too, in a number of schools the papers written in certain technical courses have been passing through the hands of English teachers. The current is setting strongly toward a more thoroughgoing coöperation between teachers of English and teachers of technical subjects; and out of the clearer understanding of our problem which is responsible for this coöperation there should come in time some improvement in the English equipment of future technical graduates.

REPORT OF COMMITTEE NO. 14, ECONOMICS.

The committee has had no meetings, but has conducted its work by correspondence as before. The committee has no recommendations to make, but submits the following progress report as information.

OPINIONS OF PRACTICING ENGINEERS CONCERNING THE TEACHING OF ECONOMICS TO ENGINEERING STUDENTS.

The committee sent the following brief questionnaire to fifty engineers who have been eminently successful in the practice of their profession with a view to ascertaining the opinions and attitude of representative engineers not engaged in educational work concerning the teaching of economics to engineering students. The letter accompanying the questionnaire made mention of the fact that no attempt was being made to seek arguments either for or against the teaching of economics, but that frank and unbiased opinions only were sought.

Group.	Number of Replies.	Question No. 1. Does Economics Aid Professional Success.	Question No. 3. Character of Course.
Civil engineers	15	12 yes	General principles 5
		1 no	Special topics 2
		2 no opinion	General principles and special topics 5
			No opinion 2
Mechanical engineers.	8	5 yes	General principles 4
		1 no	Special topics 2
		2 no opinion	General principles and special topics 1
			No opinion..................1
Electrical engineers ..	4	3 yes	General principles and special topics 3
		1 no opinion	No opinion.................1
Mining engineers	2	2 yes	General principles and special topics 2
Architects	3	3 yes	General principles and special topics 3

Not all of the engineers addressed submitted replies, the percentages of replies being as follows for the different groups: civil engineers 75 per cent., mechanical engineers 80 per cent., architects 60 per cent., electrical engineers 40 per cent., mining engineers 40 per cent. The answers to Questions 1 and 3 are tabulated below:

1. Has your experience as a practicing engineer indicated that the course in economics pursued by you while in college has aided in your professional success? ....

If you did not pursue such a course in economics, is it your opinion that such a course would materially aid in the successful practice of engineering? ....

2. If so, please state briefly in what way a course in economics has contributed to your professional success (or would contribute).

....

....

....

....

3. What sort of a course in economics would you consider the most valuable for an engineer? That is, should it deal with the general principles of production, exchange, distribution and consumption of goods, or with some specific question, such as labor and wages, banking, corporation finance, accounting commercial geography. ....

....

4. Do you object to having your replies as given quoted? ....

....

Note.—By economics as used above is meant the subject as taught in colleges under that caption and refers to the science of wealth. It does not refer to economy of design or construction as used by engineers, it being assumed that this latter subject will be taught in connection with the special technical subjects.

(Signature) ....

With regard to the answers to Question 2, the general purport was that a study of economics would enable the engineer to comprehend more fully the relation of his work to the whole economic fabric of the country. The following quoted replies to this question are expressions of fairly definite opinions on this point.

''Would give the engineer a better understanding of the results he is endeavoring to obtain.''—Albert F. Reichmann.

''It (economics) gives an engineer a broader field of thought and enables him to solve problems, especially larger projects, etc., in a more logical and better way. An engineer, in order to succeed, must not limit his education to strictly technical subjects.''—Ralph Modjeski.

''The knowledge that would have been gained through a course in economics—particularly with regard to such questions as corporation finance and accounting—I am sure would have been of great assistance to me in my work, and especially in connection with the reports to the larger corporations and municipalities during the past twenty years.''—Bion J.Arnold.

''It (economics) has caused me to comprehend better than otherwise the trade conditions of our country, the import of building materials, the several crises and panics that have occurred in the last sixty years, the wisdom or futility of undertaking certain public works and the estimation of their value and cost.''—Rudolph Hering.

''My work requires a sound knowledge of the fundamentals of financial matters, for I am frequently called upon to report upon projects and properties. Engineering is not technical only, but includes a sound treatment of the financial side of all projects. It is even more necessary for an engineer to know whether a development should be made, whether it will pay, than how it should be made.''—John Lyle Harrington.

''It (economics) enables one to view a situation broadly, considering such elements as public policy, labor, transportation, public welfare, etc., in a problem which might otherwise be studied from a narrow viewpoint of direct costs only.'' —H. J. Burt.

''I think such a course would broaden the engineer who has specialized too much in the past.''—Hunter McDonald.

''Business principles are as essential to the engineer as mathematics. The broader his education in corporation finance and allied subjects, the better his chance for administrative positions. A large percentage of engineers work for corporations and they should know all about them. I am sure that a good ground work along these lines would be of material help.''—E. J. Collins.

''In giving me a basis to which in later years I could revert and analyze the complex relations of capital and labor and the rights of the public.''—Bert H. Peck.

''A comprehension of the general laws governing the production and consumption of wealth as well as their application to the specific problems of life enters into the genesis of all successful engineering undertakings. Otherwise, the success of the undertakings depends on luck.''—L. E. Imlay.

''As the ultimate object of most engineering work is reduction in the expense of accomplishing some definite process, any training which enables an engineer to thoroughly grasp the relation between the work in hand and its financial results will contribute largely to his profession and success.''—Chas. F. Uebelacker.

''A course in economics would undoubtedly have broadened my viewpoint in the earlier work and laid the foundation for clearer thought in the executive position.''—Edwin B. Kattel.

''Some knowledge of financing, accounting, securities, business law and business management would have been of assistance.''—Charles T. Main.

Mr. Clemens Herschel and Mr. H. L. Gantt do not believe that a course in economics as at present taught would contribute to the successful practice of engineering in any way.

The following are some of the suggestions which a few of the engineers addressed volunteered as to the proper content of a course in economics for engineering students.

Dr. Rudolph Hering says: ''Most of the questions of this branch of social science are more difficult to understand than questions of mathematics, physics, geology, etc., because they are much more complex and spread over a larger field and because their practical conclusions must vary with the different stages of development as they are reached by society.''

''Of all social sciences, economics is therefore one of the greatest importance. It comes next to ethics, of which it is to some extent a corollary. And all movements to instruct our youth concerning this branch of science are to be most highly commended and furthered.''

''I am of the opinion that a competent professor should be able to impart such a course in two semesters at one hour per week.''

Mr. Gustav Lindenthal with much the same opinion suggests that economics be taught only in a post-graduate course, since ''especially the science of finance requires a very mature mind, certainly more so than [does] higher mathematics or applied science. The present theories are mostly wrong, being based too much upon authority worship and not enough upon scientific analysis, which is considered heretical by banking interests, whose constant efforts are directed towards a higher rate of interest on capital and a lowering of wages instead of the reverse principle.''

Mr. H. L. Gantt also is not satisfied with the present tenets and doctrines of economists. He says: ''To be perfectly frank with you with regard to the subject of economics, it has been impossible for me to have any patience with the ordinary textbooks on economics. They are all written apparently to support certain theories of their authors, and in many cases have but little to do with practical conditions which now obtain.''

''In general, books on economics are written from the standpoint of trade and not of production. They were perhaps more or less helpful in the days when trade was the controlling factor in the world. With the rise, however, of modern industrialism, production has become the controlling factor, which throws all previous theories out of gear. The fact that production has become the controlling factor was clearly demonstrated during the war, and is now being demonstrated in Europe. Unless the economics problem is studied and taught from this standpoint, I regard any teaching on the subject as not only of no value, but positively detrimental.''

Mr. Leonard Metcalf calls attention to the present urgent need of teaching economics. He says: ''It is my personal opinion that the obligations of institutions of learning to the public practically compel the giving of courses in economics at the present time. The present undergraduate bodies in our colleges have had practically no experience or observation in the application of such fundamental laws as that of supply and demand. They have lived since they began to notice such matters in the press and conversation, in a thoroughly abnormal era, with government control of prices, labor and industry. They accept without question as normal the results attained, failing to recognize as older, experienced men do, that these results were possible only with the mind set on one purpose—the winning of the war. They do not recognize that in times of peace, many and probably the majority of men would not tolerate what they accepted willingly, or permit the President and Congress the full measure of power that they willingly gave during the war. Therefore, it seems to me that the most difficult task faced by the institutions of learning the world over is giving the student, in a way that will stick in his memory, a clear picture of the world up to this time and of the operation of well recognized economic laws under normal conditions.''

''Unless our institutions of learning and public leaders recognize this and do what they can to broaden the horizon of the student body, there will be tried many economic theories already demonstrated as unsound, an impetus will be given to uncontrolled radicalism and thoughtless socialistic propaganda. There never has been a time probably when there was greater need of open-minded and careful review of old theories than at the present time, but it would be deplorable to lose the crystalized experience of past centuries.''

Mr. B. H. Peck outlines somewhat in detail the character of a course in economics that he would consider the most beneficial. ''It (the course in economics) should, in my opinion, not be presented by one man, since we all have our peculiar biases and beliefs on subjects of this nature. If I were framing such a course, I would include lectures by financial men who could explain the flow of money to certain fields, and the interest requirements of invested capital; by labor representatives, who could state the attitude of labor and its aims; by an advocate of municipal or government ownership; by a practical operator of a large enterprise; by a tax commissioner; by a public utility commissioner, etc. Along with these, I would study Smith's 'The Wealth of Nations' or its modern equivalent."

A perusal of the replies reveals a notable lack of uniformity and definiteness of conception on the part of practicing engineers as to the use of the term economics. To some, it apparently applies to the actions of social communities, while to others, it is limited to the details of more or less private business transactions.

The general tenor of the replies is in accord with the report of the committee last year, wherein it was recommended that the formal study of economics consist of a three-hour outline course in the general principles of the subject. However, there is a suggestion in a number of the replies that sufficient time should be given to some special topics, such as labor problems, commercial geography, accounting, corporation finance, public finance, etc., to cause the student to appreciate their importance and to grasp their significance.

Movement Toward Extension of Teaching Economics.

The Bureau of Education in the Department of Interior is fostering the development of courses in "Commercial Engineering" to be given in schools of commerce and to embrace the fundamentals of engineering courses with extensive studies in economics and allied subjects. The courses are planned with a view to preparing men for administrative positions with large corporations and other business concerns. A preliminary conference was held at St. Louis, February 22, with Dr. G. L. Swiggett, of the bureau, as chairman. A second conference was held at Washington, March 31, and it is proposed to hold a third at the same place on Monday and Tuesday, June 23 and 24, immediately preceding the annual meeting of the S. P. E. E. This conference group has not yet issued any conclusions for publication other than to make the following tentative recommendations:

1. That from twelve to eighteen semester hours be required of all engineering students covering the following subjects: general economics, cost accounting, business organization and business law.

2. That for engineering schools desiring to extend further the commercial or industrial aspects of engineering, the following subjects are recommended as electives: labor and employment, corporation management and finance, statistics, marketing, scientific management, psychology, transportation, political science.

3. That the economic phases of engineering be emphasized in engineering instruction wherever possible.

A few schools have already instituted courses of the character contemplated by this conference either as a department of the engineering division or as a coöperative arrangement between the engineering division and the school of commerce. Massachusetts Institute of Technology has such a course under the heading Engineering Administration, with three options as follows: civil, looking to administrative positions in transportation, hydraulic power and construction enterprises; mechanical, in preparation for similar positions in machine manufactures; chemical, in preparation for such positions in various chemical manufactures. The University of Kansas, in the School of Engineering, offers a similar group of courses under the heading Engineering and Administrative Science, with two options, civil and mechanical, and Pennsylvania State College offers a course called Industrial Engineering that is similar to the above. The universities of Illinois, Wisconsin and Ohio maintain coöperative courses in transportation or other phases of commerce which combine engineering with economics in the schools of commerce.

COURSES IN CITIZENSHIP.

Recently, the University of Illinois voted to institute a course in ''citizenship'' to be required of all students in the university. The schedule will consist of two courses of three hours each, the first including history and those phases of economics and political science that are fairly definite and generally accepted, and the second, those phases of economics and politics that are more or less controversial in their nature. The scheme is an outgrowth of the war issues course of the S. A. T. C. regime.

The oject apparently is not so much to furnish the student with information and training that may be of direct professional benefit as to equip him for the duties of citizenship. The courses will be taken by all students subsequent to their freshman year, preferably in the junior or senior year.

The University of Wisconsin has installed a similar scheme under the title of "Americanization" with a professor in charge.

Influence of Present Economic Status on Instruction in Economics.

The committee desires to call attention to the desirability of recognizing the abnormal state of industrial affairs in connection with the teaching of economics and to urge the importance of laying emphasis on sound economic doctrine, such as is the best product of past human experience and such as will lead to stable industrial conditions, rather than spending the time of the class in the consideration of radical and untried theories of social and industrial organization. The teaching of sound economic doctrine in colleges will be one means of hastening the inevitable return of the economic pendulum to the mean position which is so necessary for further industrial development.

The extensive realignments in domestic and foreign trade render imperative a study of commercial geography on the part of engineers interested in manufactures and in markets. Attention of students should be called to the altered position that this country now holds in the world's markets and commerce, to the changed labor situation, etc. This can be accomplished best perhaps by some other instrumentality than formal class exercises, such as posting bibliographies of meritorious articles, etc.

INTEREST IN ECONOMICS.

The committee believes that an endeavor should be made on the part of engineering faculties to aid in overcoming the apathy generally manifested by engineering students towards economics and to foster in them a live interest in the subject. Conscious effort in this direction is probably the only means of securing satisfactory results in the subject to engineering students.

Respectfully submitted,
A. B. MCDANIEL,
E. B. PAINE,
W. G. RAYMOND,
C. C. WILLIAMS, *Chairman.*

Professor G. F. Swain, the other member of the committee, declined to approve the above report.

THE METRIC SYSTEM IN ENGINEERING.

BY FREDERICK A. HALSEY,

Member and Commissioner of American Institute of Weights and Measures.

(Presented at the meeting of Section D, A. A. A. S., Baltimore, Md., December, 1918.)

I desire to introduce the subject proper of this paper with a few remarks regarding the value and importance of standardized things.

We make infinite effort to standardize mechanical constructions, and when the work is done the standards accomplish their purpose so perfectly and work with so little friction that we forget the purpose for which they were established. Most of those who oppose the metric system, when confronted with the suggestion of a change, throw up their hands with the remark ''Think of the cost of scrapping our special tools, fixtures, and gages and replacing them with others made to the metric system.'' While this instinctive objection is of large importance, it represents but a trifling fraction of the value of standardized constructions and in order to make this clear, I will point out two examples.

The couplings with which the hose ends of railway car air brakes are connected were standardized, that is, made interchangeable, many years ago at the works of the Westinghouse Air Brake Company. Because of that standardization, railway cars—both passenger and freight—when fitted with air brakes, may be made up in trains regardless of the railroads of their origin and transported throughout our country. What would be thought of a man who would estimate the value of those standardized couplings in terms of the cost of the special tools with which they are made in the works of the Westinghouse Air Brake Company? Is it not perfectly clear that their real value lies in the results which they accomplish, that is, the possibility of interchanging cars between railroads?

As another illustration, consider standardized pipe fittings. Because those fittings are standardized, they are made by the million and may be bought at trifling cost in any pipe fitting shop. The piping of a building consists of little more than cutting pipe to length, threading its ends with standardized dies and assembling the resulting pipes with their connections and fittings. Consider the conditions that would obtain when piping a building for steam, water and gas were it necessary to make each fitting for its place and to order, and then ask yourselves what part of the real value of standardized pipe fittings is represented by the cost of the taps and dies with which the threads upon the pipe and fittings are made. Additional examples could be given without number, but these two should be sufficient to show that the value of standards lies in the results which they accomplish and not in the tools with which they are produced.

Consider, next, the result of attempting to change the sizes of air brake hose couplings to metric dimensions and the infinite cost and confusion that would result. Air brake hose couplings are standardized in order to facilitate the interchange of cars which the present standards accomplish perfectly. Were those couplings changed to metric dimensions no gain would result since the new couplings would accomplish their purpose no better than the old. Similarly, pipe is made to carry steam, gas and water and if our pipe sizes were changed to metric dimensions, the new pipe would accomplish that purpose no better than the present pipe, while in both cases the cost measured by the resulting confusion would be prohibitive.

These things will not be changed because they cannot be. We may pass laws for the adoption of the metric system until the crack of doom, but such things will remain as they are. They supply two illustrations that might be repeated to the point of weariness, but they are sufficient, and they point out what we must consider in the event of the adoption of the metric system, namely, the use of that system in connection with standardized things made to English dimensions for the indefinite future, for the simple necessity of continuity makes the continuance of the existing sizes of standardized things imperative. We must consider, therefore, not the hypothetical condition of the metric system standing alone, but the actual condition of the conjoint use of both systems—one in materials of construction and the other in engineering calculations.

Let us, therefore, consider the conditions to be met after the metric system has been adopted but while existing structural standards continue in use. To make this clear, I have selected some of the simplest possible illustrations in order to point out a universal principle, and this is the real subject of my paper.

TECHNICAL LITERATURE MUST BE REWRITTEN.

Take the simplest possible case—finding the size of a bar of steel to carry a given load in tension. We place the load on one side of an equation of which the other side includes as factors the required area of the bar, the tensile strength of the material and the factor of safety. We write the load in kilograms and the tensile strength in kilograms per square centimeter and find the required area of the bar in square centimeters, to be at once confronted with the fact that all American merchant bar is rolled to diameters in inches. We, like metric countries, have plenty of tables of areas, but in all cases they connect diameters and areas in the same system of units. With either system used alone we would, after finding the area, take the diameter directly from a table; but we must now find the diameter in inches from the area in square centimeters by calculation, until such time as someone has prepared and printed a transition table giving diameters in inches and areas in square centimeters, or, by first finding the diameter in millimeters and then converting the result to inches.

An alternative procedure is possible. The formula might be altered into a transition formula giving the tensile strength in kilograms per square inch and the area in square inches. We could then use existing tables of areas, but in addition to the transition formula we would need transition tables giving strength in kilograms per square inch. Such tables must be prepared and printed before this procedure is feasible. Whatever the procedure, we shall at the end have the same result —that is, the same load and the same bar, to get which we have discarded existing tables and made the calculations which the tables have been prepared to avoid.

I have gone into this in, perhaps, tedious detail, because it illustrates in the simplest possible way a universal principle: Whenever basic quantities—loads, powers, velocities, pressures, capacities, etc.—are expressed in one system of units while commercial materials are made to, and their properties are recorded in another, we have a conflict in every application of one to the other. Existing formulas, English or metric, do not fit, and existing tables do not apply. To suit this condition, our technical literature must be rewritten from the beginning in transition form for use so long as existing commercial sizes of materials continue in use to be discarded when, and if, the transition period comes to an end.

Illustrations of this may be multiplied to the point of weariness. Suppose we are laying out a belt transmission. The formula for the capacity of belts includes the velocity and width of the belt, with other factors. Our reference books contain charts that give the effects of speed, centrifugal force, thickness, type of joint and arc of contact almost at a glance, but these we must discard and make the calculations which the charts have been prepared to avoid.

With the load in metric units, this calculation gives us the velocity in meters per second and the width in millimeters; but when we take up the matter of pulleys, we find that all pulleys made in this country are made to inches of diameter which, multiplied out, give the circumferential velocity in feet per minute, and this result we must equate with belt velocities in meters per second. Ultimately, we must use the pulleys we can buy—that is, of English diameters and widths.

Going further, we determine the shaft sizes, to be confronted with an applied torque in meterkilograms equated with the resisting torque of a shaft in inches of diameter, on which the only available information as regards torsional strength is in pound-inches. As before, we need a transition formula and tables giving, in this case, resisting torques of shafts in kilogram-inches, and as before, we get the same result in the end.

Since closeness of fit is not involved, we may still place a belt of metric width on English pulleys, shafts and bearings; and then, if we are true-blue metric advocates, we will shout from the house tops: "We have adopted the metric system."*

Do we calculate the diameter of a pipe or a boiler for a given pressure, it is the same. From the pressure in kilograms per square centimeter we get the stress in kilograms per square centimeter, to be equated with the strength of the material, of which the thickness is in inches, and all available data for strength are in pounds per square inch.

Do we calculate the weight of structures, it is again the same. We have extended tables of the weight of materials in pounds per foot of length; but if we are to use the metric system with these materials, we must have transition tables for I-beams, channels, angles, bars, pipe, sheets, etc., giving weights in kilograms per meter of materials rolled to inches of cross-section.

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* This is not sarcastic, but descriptive of every "adoption" of the system of which I have any knowledge, all such adoptions being partial. The metric enthusiast makes the easy changes. He does not make the difficult ones, but he invariably talks as though he had made them all. He regards the difficult changes that he has not made as not worth counting. If we are to study difficulties, we must study difficulties, the changes which he does not make because he cannot, and does not count because it suits his purpose not to, being the very ones that must be counted.

All Technical Tables Must be Recalculated.

The matter of the tables is perhaps of even greater actual, though less fundamental, importance than the formulas. Our tables are now so complete and comprehensive that the large majority—in some applications perhaps 80 per cent.—of such problems are solved by direct reference to them, resort to the formulas being had only for occasional cases beyond the range of the tables. All our tables are based on one system of units. We have no tables for a mixture of units; and until someone has been good enough to prepare and print them, we must resort to calculations which the tables were prepared to avoid and, so long as existing materials are used, get the same result in the end. What is gained? What is it all for?

As another illustration consider the most ordinary problem in hydraulics—finding the diameter of a pipe to carry a given quantity of water. Hydraulic tables are remarkably complete, and most such problems are solved by simple reference to them. Using the metric system, we have the head, the velocity and the length of the pipe in meters and the discharge in liters, but the diameter of the pipe is in inches. We have neither formulas nor tables fitting this condition, and again we must calculate and convert, our calculations in this case involving the square root of the fifth power in millimeters of pipe diameters in inches. The results of these calculations we now take directly from the tables, and again the final result is the same.

In the foregoing cases we have to deal with repeated conversion of units, which while bad enough, is not all. Let us therefore consider one more everyday case in which even this will not answer—finding the size of an I-beam to carry a given load. Our span is in meters, and our load in kilograms, but the cross-sections of our beams are in inches. What shall we do with the moment of inertia? In the moment of inertia of an I-beam four dimensions enter, two by their first powers and two by their cubes. There is no possible conversion factor between English and metric moments of inertia. Moments of inertia of all common cross-sections in English units have been worked out and tabulated in great profusion, but we cannot use them even by conversion. Until new transition tables of metric moments of inertia of sections rolled to inches have been prepared and printed, every calculation of an English section I-beam for metric loading involves the calculation of the moment of inertia for the cross-section or, as an alternative, the use of English units for the load and span. Which will be done?

A Few Examples.

Following is a list of a few such tables that will be needed: Square roots of fifth powers in millimeters of pipe diameters in inches; weight of materials in kilograms per cubic inch; board measure; section moduli, radii of gyration and squares thereof and areas of rolled sections; friction head and discharge of pipe; weight of all rolled sections and of rivets, bolts, bars, balls, plates, pipe—cast, welded, cold drawn, etc.; strength of columns and pillars; strength and weight of chain and rope—wire and hemp; weight and other properties of brass copper and lead pipe and other products of these materials; strength and other properties of timber beams, columns, etc.; properties of boiler and condenser tubes; bursting and collapsing strength of pipe; pipe flanges; flow of air in pipes; all screw-thread and gearing tables; chain-driving tables; the strength of riveted joints; angles when considered as tapers per foot; chord-spacing tables of circles; weights and other properties of all materials made to wire and sheet metal gages; loads on bearings; strength of shafting; strength and deflection of springs; all machine-shop standards—tapers, dovetails, machine parts and details, press and running-fit practice, etc.; performance and power requirements of machines in endless variety; strength of materials of all kinds and grades; steam-engine and boiler practice from the ground up. But the list is endless. Open any engineer's reference book and look for a formula or a table (other than mathematical tables, which are universal) that will be useful during the transition period, and you will look long before finding one.

Of these two requirements in preparation for the transition period the transition formulas will come first. We shall then be in shape to use the metric system, provided we are willing to discard all tables that have been prepared through many decades to shorten, and, in many cases, eliminate calculations, the physical result being the same in all cases and the psychological result the proud and superior consciousness that we are "using the metric system."

We are to discard these devices for saving time in calculations and make the calculations which they make for us, in the cheerful belief that the loss will be compensated with a balance to the good through the magic of the "beautiful interrelation and correlation of the units." This is the hook which engineers are asked to swallow, and by all that is logical, the proffered bait is economy of time in calculations!

One who is familiar with these problems will recognize that many of them must be solved by successive approximation or trial and error. With the tables we soon find the appropriate size; but when calculation is resorted to, we must calculate and recalculate until a satisfactory result is found.

All this leads to but one conclusion: So long as existing commercial sizes of materials of construction endure, no sensible man will resort to metric calculations with them more than once.

WHO WILL LEAD THE PROCESSION?

Will the rolling mills lead in this change? For them to do so involves the duplication of sections and assortment of rolls, the doubling of the number of changes of rolls, with the resulting loss of time and of the warehouse stocks to be carried. Incidentally, they will recalculate and reprint their tables of the properties of their sections, first in transition form for existing sections and then in metric form for the new sections, supplying also, meanwhile, the existing tables for those recalcitrant engineers who prefer the old and simple way. When it is all done, the new sections will do their work no better than the old, and we cannot look for enthusiasm in that quarter.

The doubling of stocks to be carried is the minimum involved. During the transition period we will have occasion to put English pulleys on metric shafts, and metric pulleys on English shafts, and we shall therefore require the following pulleys: English bore and rim; metric bore and rim; English bore and metric rim; metric bore and English rim. A pulley manufacturers' warehouse stock now comprises about 10,000 pulleys. The multiplication of this list by four will curb enthusiasm in that quarter.

In pipe fittings the case is equally serious. The new sizes of pipe must be connected with the old, and the most simple fittings—nipples and couplings—would be multiplied by three and the tees and crosses by not less than six. As before, the new pipe and fittings will carry water, steam and gas no better than the old. These illustrations can be extended indefinitely, but I must stop somewhere.

Shall we then conclude that the change is impossible and therefore not to be feared? That would be as shallow, as stupid and as fatal as the worst of the metric conclusions. Let no one forget that, while a complete change is impossible, a partial change is easy—as easy as going down a toboggan slide—and this partial change is exactly the thing that leads to the welter of confusion which I have endeavored to picture. Let no one imagine that in the absence of compulsory law he can use it or not as he sees fit. Once here, we must all deal with it and use it, whether we wish to or not. In this matter no man lives unto himself. Every metric stone thrown into our industrial lake is the center of an expanding area of disturbance. If this paper means anything, it is that a partial change spells total confusion and that every introduction of the system is to be fought as the intrusion of an enemy of our industrial life.

COOPERATIVE COURSES IN COMMERCE AND ADMINISTRATION.

University of Cincinnati.—The college of engineering and commerce at the University of Cincinnati announces the inauguration of a five-year coöperative course in commerce and administration beginning September 22, 1919.

This course is planned to meet a demand on the part of the larger business organizations for men thoroughly trained not only in the commercial side of business enterprises, but in the production side as well. The relationships between production, marketing, accounting, and finance are so close that a knowledge of all of them is essential to work in the higher commercial positions related to large business undertakings. The coöperative course to be inaugurated next fall will include theory and practice in all of these phases of business.

The general plan is the same in detail and operation as in the coöperative course in engineering; that is to say, students will work alternating bi-weekly periods at practical work in business concerns and theoretical work in the university. The practical work during the first years will be in certain carefully selected departments of production, in the shipping departments of large concerns, in the traffic departments of railroads, and in the planning departments of factories. This work will cover a period of about two and one half years, after which the student will be transferred to the commercial side of business for the next two and one half years. In the university, the courses will follow the same general trend. The earlier years will be given to mathematics, fundamental sciences, and to engineering; and the latter years to commercial subjects such as accounting, finance, marketing, business law, management, and so on. As in the coöperative engineering course, students will be paid for their practical work in business concerns just as the engineering students are paid.

The requirements for admission are the same as those shown on page 15 in the announcement of the college of engineering. The rates for tuition and fees are also the same as in the engineering course. In fact, all of the details of operation, cost, and wages are just the same as those announced for the engineering course.

Thus it is intended to prepare students for careers in the commercial world as thoroughly and as broadly as they are trained for work in the various fields of engineering, and to fit them upon graduation to take positions of responsibility in commercial and industrial concerns.

Upon successful completion of the course, students will be given a degree of bachelor of science in commerce.

The night courses in commerce at the university which have been given heretofore will be continued and will be amplified by the addition of fundamental courses in production and management.

Requests for additional information should be addressed to the College of Engineering and Commerce, University of Cincinnati.

BOOK REVIEW.

Descriptive Geometry. By W. H. MILLER, M.E., Head of Department of General Engineering Drawing, University of Illinois. Fourth edition. v + 176 pages. John Wiley and Sons, Inc., 1918.

This edition is slightly revised to cover some betterments in the typography. Otherwise it is the same as the previous issues which have proven so acceptable.

The subject matter of the text is laid out with the idea in mind that the teaching of students to think logically is of more importance than the technology of the subject. Thus the student who completes this course not only has a complete knowledge of descriptive geometry, but he has developed an ability to apply the principles to other problems which he may meet.

M. I. G.

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